Assessing indicators of Climate Change in Gandaki River Basin and Engaging Local Communities for Long-term Monitoring

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Royle's Pika *Ochotona roylei*, climate indicator species in the CHAL, Photo By: Mr. Hari Basnet/SMCRF

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Cover Photo: Trans-Himalayan region (Jomsom) along with Himalayan range on the south horizon, Himalayas are one of the most climatic vulnerable site in the world (Photo by Mr. Sanjan Thapa/ SMCRF)

Photo by: Mr. Hari Basnet, Mr. Deelip Chand Thakuri, Mr. Sanjan Thapa, Mr. Tejab Pun, Mr. Bishnu Achhami

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ABBREVIATIONS AND ACRONYMS

ACAP:	Annapurna Conservation Area Project
BCF:	Barandabhar Corridor Forest
CCM:	Climate Change Monitoring
CHAL:	Chitwan-Annapurna Landscape
CMIP5:	Coupled Model Intercomparison Project, Phase 5
DBH:	Diameter at Breast Height
DFO:	Division Forest Office
DHM:	Department of Hydrology and Meteorology
DNPWC:	Department of National Parks and Wildlife Conservation
DoFSC:	Department of Forests and Soil Conservation
EN:	Endangered
FAO:	Food and Agriculture Organization of the United Nations
GPS:	Global Positioning System
ICIMOD:	International Center for Integrated Mountain Development
IPCC:	Intergovernmental Panel on Climate Change
IUCN:	International Union for Conservation of Nature
LC:	Least Concern
NT:	Near Threatened
NTNC:	National Trust for Nature Conservation
PAs:	Protected Areas
PMP:	Permanent Monitoring Plots
PPF:	Panchase Protected Forest
SMCRF:	Small Mammals Conservation and Research Foundation
TAL:	Terai Arc Landscape
USAID:	United States Agency for International Development
VDC:	Village Development Committee
VU:	Vulnerable
WWF:	World Wildlife Fund

PROJECT SUMMARY

Climate change has been identified as a driver of change across the globe, already stressing ecosystems and affecting biodiversity within those ecosystems. Nepal is one of the most vulnerable countries to face negative consequences of climate change in biodiversity and human wellbeing. To monitor any possible changes for the long-term across various eco-regions/altitudinal zones identified in the Gandaki River basin, WWF Nepal/ Hariyo Ban Program has established 12 virtual plots in areas which are projected to be either vulnerable or resilient to climate change in the long run. An important transit route for migratory birds and home to endangered species like Greater One-horned Rhinoceros, Tiger, Asian Elephant, Snow Leopard, Red Panda and Himalayan Black Bear showcases the richness and importance of the area to biodiversity conservation. Over four million people living within this landscape are directly or indirectly dependent on the natural resources of this area. This landscape consists of six of the Protected Areas of our country and important forest areas like Panchase Protected Forest, Barandabhar Corridor Forest and other government and community forests. A detailed study on faunal diversity along the climate change monitoring plots in Gandaki River basin was done along with identifying the potential indicator mammalian species. Capacity development of local people as a part of strengthen mechanisms for local level monitoring for long-term monitoring was done along with analysis of climate pattern in each plot in the project sites.

The survey was conducted from November 2019-January 2020 in 12 climate monitoring plots in Chitwan Annapurna landscape. In each plot, five systematic transect were laid in which sign survey was carried out, 10 camera trap was placed for seven days to record the illusive and nocturnal mammals, TubeTrap and Sherman's trap were used for small mammals while mist-net were used to survey the bats. Mackinnon's Listing Method was used for bird surveys while purposive line transect were laid in the most potential site to record the herpetofauna and

butterflies. Quadrat sampling method was used for previously identified climate-indicator species of vegetation in the plots.

Based on mammalian data, climate change indicators and vulnerable species vulnerability assessment was conducted after selecting 13 species. Climate Change Species Vulnerability Assessment by WWF was adopted for the project and the species were assessed based on their sensitivity, adaptive capacity and exposure to climate variability. A training module was created for capacity development to engage local communities. Field based training was conducted to engage the participants practically for monitoring and use of various monitoring tools were taught in the field. Questionnaire survey was also conducted among the adults of the participants who were familiar with experiences of climate impacts in agriculture and livelihood. The questionnaires were created and provided by WWF-Nepal prior to field work and questions focused on the type of crops used and the impacts natural calamities were bringing in recent years.

From the assessment conducted, 54 species of mammals, 284 species of birds, 107 species of butterflies and 13 species of herpetofauna were identified from the 12 permanent plots. Eight species of mammals and eight species of birds listed as globally threatened category while 12 species mammals and 16 species of birds are listed in the national threatened category. Diversity of mammals and Birds were higher in the lower elevation plots (Barandabhar and Rampur) while fewer species were recorded from the higher altitude. Our mammals and bird diversity along the elevation gradient shows the general pattern of species i.e. the decline of species richness with increasing elevation. Our climate indicator assessment shows that seven species (Himalayan Black Bear, Snow Leopard, Bengal Tiger, Woolly Hare, Royle's Pika, Asian Elephant and Greater One-horned Rhino) shows more vulnerable to climate change and may be these species can be indicator mammalian species in the study area. Larger animals like Asian Elephant and Greater One-horned Rhinoceros are even more vulnerable to climate change due to their longer generation time, large body mass and freshwater requirement to combat heat from their body. However, small mammals like Royle's Pika that heavily depend upon winter snow's thickness for thermoregulation could suffer even harsher climate change impacts ifprompt conservation action isn't conducted. Each species, large or small, must be assessed for climate change vulnerability in order to encompass global conservation of wildlife. In terms of recent climate scenarios, local interaction pointed out the communities were facing untimely heavy rainfall followed by snowfall. Upon analyzing the climatic data of the different plots, it was concluded that all the plots are currently facing a gradual increasing trend of temperature in the following years. Yearly temperature pattern in the CHAL area shows an increase in the temperature in all stations. The lowest temperature, 1.06°C rises in Barandabhar while highest in Bhadaure_Harpankot plot by 1.2°C in the past 50 years from now. Although temperature changes from 1.06-1.20 on average, temperature in the last two decades were remarkable. On average in the CHAL area, temperature had risen by 1.13°C. The value is higher than the global average raise in temperature. However, although there were high and low frequencies in different years, precipitation in the CHAL area was shown to be steady. This had certainly shown impacts in the communities as questionnaires conducted within the local people showed that their livelihood through agricultural crops were being affected due to different climatic variability. This along with issues of human-wildlife conflicts could be a major risk factor for the decline or extinction of the endangered species like Snow Leopards and Himalayan Black Bear that are known to travel towards human settlements for food. Enhancing conservation activities by engaging local stakeholders hence is an essential part to build bridges between human and wildlife conflict.

1.1 INTRODUCTION

1.1.1 GENERAL INTRODUCTION

Global climate change has threatened global biodiversity, ecosystem function, and human well-being, with various publications demonstrating impacts across a wide diversity of taxonomic groups, ecosystems, economics, and social structure. Now, anthropogenic climate change has been evolved as one of the new threats to biodiversity in the global scenario leaving habitat loss, overexploitation and invasive species behind (Williams et al., 2008). Based on regional studies, the Intergovernmental Panel on Climate Change (IPCC) estimated that 20–30% of the world's species are likely to be at increasingly high risk of extinction from climate change impacts within this century if global mean temperatures exceed 2–3°C above pre-industrial levels, while prediction that 15–37% of species could be 'committed to extinction' due to climate change by 2050 (Thomas et al., 2004). Although this Climate Change is one of the serious global problems, its impacts differ from region to region and country to country (Adger et al. 2005; Kasperson and Kasperson 2001).

The early signs of human-induced climate change seem to be seen upon us by thorough responses of biota which include changes in physiology, productivity and growth. Not only this but changes in species distribution, change in migration pattern and range shifts are major effects on biodiversity due to human-induced climate change (Parmesan 1996; Parmesan et al., 1999). In an ecosystem, a slight disturbance can modify the phenology and distribution of the species which may bring a major transformation in the ecosystem (Gritti et al., 2005). Within the field of conservation biology as a whole, and protected area management in particular, it is becoming increasingly urgent to develop predictions of how this significant change in the earth's environment will affect the abundance and distribution of species. These predictions need to be temporally and spatially explicit, to allow managers and designers of protected areas to plan for maximizing migration potential for the greatest number of species possible.

Seven selected locations within CHAL show a progressive increase in maximum temperatures in all regions during that period which has been projected by an analysis of 30 years (1979-2010) of meteorological data. However, the exact rate of temperature increase differs from place to place, from 0.039℃ in Lumle, Kaski, to 0.021℃ in Chame, Manang. The field level focal group consultation and key informants at different locations covering all physiographic zones lead to the conclusion that the temperature in CHAL has been steadily increasing, but the rate of increase is variable across different regions (WWF Nepal, 2013). The annual precipitation differs in the overall CHAL area in a considerable manner. Long term analysis of precipitation conducted between the year 1979- 2010 indicated that Lumle, Kaski received the highest average total annual rainfall (5,496.3 mm) and Jomsom, Mustang received the lowest average total annual rainfall (269.6 mm) which are the locations that received highest and the lowest rainfall during the period (WWF Nepal, 2013). Likewise, the local level focal group and key informants showed that more than 80 percent of the communities have experienced an increase in water stress due to decreased rainfall and delay (by 15 to 20 days) in monsoon arrival. Erratic rainfall, high intensity rainfall, and uneven distribution of rainfall were other common observations of local people (WWF Nepal 2013).

Not only biodiversity but poor and agrarian communities of the developing countries are affected most by climate change in agriculture because of poor adaptive capacity and limited access to alternate means of production and agriculture is one of the most susceptible sectors (IPCC 2007; Skoufias et al., 2011). Livestock is an essential part of the farming system in the socio-economical life of Nepal that contributes nearly 26% to the total agricultural gross domestic product (MOAD 2012) in the country. Almost 87% of the households in the country keep some kind of livestock (IRIN 2013). Grain cultivation and livestock production are inseparable livelihood activities in

Nepal. These activities complement each other, and the majority of households combine subsistence crop production with small numbers of livestock and thus are referred to as mixed agro-live-stock smallholders. However, there is very little information on how vulnerable mixed agro-livestock smallholders are to climate change and how vulnerability differs across different agro-ecological zones of Nepal.

The Hariyo Ban Program is a five year USAID funded program aiming to reduce adverse impacts of climate change and threats to biodiversity. The three objectives of the project are:

- *Reduce threats to biodiversity*
- *Ensure effective sustainable landscape management with strong emphasis on reducing emission from deforestation and forest degradation (REDD+)*
- *Increase capacity to adapt to adverse impacts of climate change*

The programs' cost cutting themes on livelihood, gender equality and social inclusion (GESI) and governance has been the prime driving source in two implemented landscapes: the east-west Terai Arc Landscape (TAL) and the north-south Chitwan Annapurna Landscape (CHAL). In the line of climate change affecting not only the quality of ecosystem services, but also the local communities, WWF-Nepal has prepared a number of Community Adaptation Plans (CAPs) in the TAL with the objective to reduce vulnerability of the ecosystem and communities to the impacts of climate change. These CAPs are implemented and are being monitored by the local communities of the respective area. Despite several independent researchers and organizations regularly monitoring the impacts of climate change in different regions of Nepal, there is the paucity of time series data to understand the long term ecological, social and environmental impacts of climate change. Hence, it is extremely important to establish baseline data to understand the long term impacts of climate change on ecosystems and communities.

To monitor any possible changes in the long-term across various eco-regions/ altitudinal zones identified in the Gandaki River basin, WWF Nepal/ Hariyo Ban

Program has established 12 virtual plots in areas which are projected to be either vulnerable or resilient to climate change in the long-run. This will include the impacts of climate change on the composition of forest ecosystems and resulting impacts on the adjoining human communities through possible changes in ecosystem services, agriculture, water resources and livelihoods. In 2014 Hariyo Ban Program established a baseline for these 12 plots and plans to document changes in the future through the engagement of local communities, citizen scientists, academic institutions and researchers. These twelve plots (each plot is 2x2 km in area) are located along the elevation gradient to capture the major vegetation and forest types. WWF Nepal/ Hariyo Ban Program has also identified the nearest 12 local schools which can potentially be engaged in long-term local level monitoring of climate change impacts in the basin. These schools have also been oriented on the process and objectives of the monitoring. A study has also documented possible indicators species of flora and developed a monitoring matrix for local communities which may need to be revisited and finalized during the period of this assignment.

1.1.2 Aims and Objectives

The main objective is to conduct detailed study on identified indicator species (flora and fauna) of climate change across the Gandaki River basin in the given plots based on the previous studies conducted and strengthen mechanisms for local level monitoring for long-term monitoring.

The specific objectives were:

- ➔ To conduct detailed surveys of biodiversity in monitoring plots,
- ➔ To refine and finalize identified indicator species (events/life history traits) and monitoring mechanism for local level monitoring of flora and fauna on the basis of standardized checklist;
- ➔ To identify areas of support (capacity, vital resources etc.) for long-term monitoring and engagement with each local school and key stakeholders to sustain monitoring mechanisms and support relevant areas.
- ➔ To analyze the temperature and precipitation patterns gathered in the monitoring stations in/around the monitoring plot

1.2 Materials and Methods

1.2.1 Study Area

Chitwan Annapurna Landscape is the continuous geographic area in central Nepal ranging from subtropical in the lowlands of Terai (200m above sea level) to alpine in the high mountains and Trans Himalayan region (above 4000m). It covers an area of about 32,090 sq. km. and is well known for its floral and faunal diversity. The CHAL area falls partly within the Sacred Himalayan Landscape that stretches up to Bhutan in the east till Nepal's Kali Gandaki River in the west. It exhibits much scenic beauty, ranging from the rain shadow of the trans-Himalayan area and the snowcapped mountains of Annapurna, Manaslu and Langtang in the north, descending southwards through diverse topography to the mid-hills, Churia range and the flat lowlands of the Terai (Figure 1, Table 1). It contains seven major sub-river basins: Trishuli, Marsyangdi, Seti, Kali Gandaki, Budi Gandaki, Rapti and Narayani.

CHAL has high biodiversity value and rich natural and cultural heritage. It is an important transit route for migratory birds and is home to endangered species like Snow Leopard, Red Panda and Himalayan Black Bear. Over four million people have been living within this landscape and their lifestyle, livelihood and wellbeing being very much dependent on the natural resources of this area. Within this landscape, there are six Protected Areas (PAs) and important forest areas like Panchase Protected Forest (PPF), Barandabhar Corridor Forest (BCF) and other government and community forests. In order to establish a baseline data for the biodiversity of the area for improved conservation strategies and to monitor the impacts of climate change on those species, this study was carried out in 12 various permanent monitoring plots (PMP) (2 km^2) designated within the CHAL.

Table 1: Information of the permanent monitoring plots of Gandaki River Basin

S.N.	Plot name	Rural/Municipality/District	Lat	Lon	Elev. (m)	Physiological Zone
1.	Chhonhup	Lo Manthang RM, Mustang	29.28760	83.9206	4740	High Mountain
2.	Bhena	Lomanthang RM/Barhagaun Muktikhsetra RM, Mustang	28.98414	83.81478	3900	High Mountain
3.	Jomsom	Gharapjhong RM, Mustang	28.78377	83.76080	3000	High Mountain
4.	Kunjo	Thasang RM, Mustang	28.65343	83.61687	2700	High Mountain
5.	Narchyang	Annapurna RM, Myagdi	28.52126	83.67415	1888	Hill
6.	Bhadaure Deurali	Annapurna RM/Modi RM, Parbat & Kaski	28.25656	83.81292	1500	Middle Mountain
7.	Harpankot	Pokhara Lekhnath, Kaski	28.24030	83.85005	960	High Mountain
8.	Asardi-Malung	Galyang M/ Rambha RM, Palpa & Syangja	27.91395	83.66327	450	High Mountain
9.	Rampur-Sakhar	Rampur/ Chapakot M, Palpa & Syangja	27.88452	83.90885	390	High Mountain
10.	Kabilas	Bharatpur MC	27.78678	84.50937	1028	High Mountain
11.	Kaule-Shaktikhor	Ichchhyakamana RM/ Kalika M, Chitwan	27.77920	84.60609	1780	High Mountain
12.	Barandabhar	Bharatpur MC, Chitwan	27.57169	84.44277	205	Siwalik

RM: Rural Municipality; M: Municipality and MC: Metropolitan City

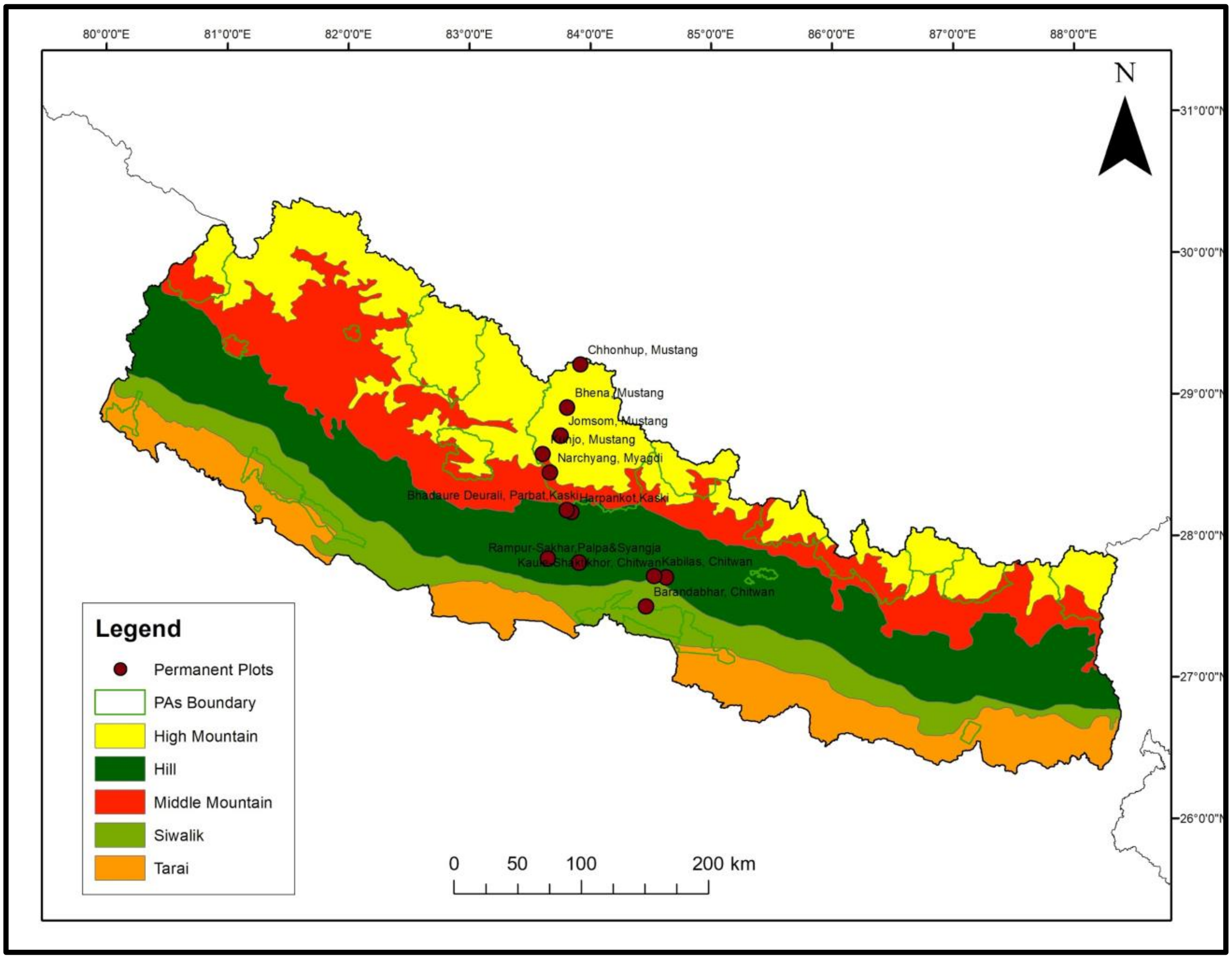


Figure 1: Map of project area showing permanent plots in physiographic zone

2.1 BIODIVERSITY SURVEY

2.1.1 Introduction

The simplest and most strongly supported response of species towards climate change is they shift their range geographically to track their climatic niche. Some of the species which cannot shift geographically can be extinct due to this climate change which are known to be Climatically Vulnerable species (Ashcroft, 2010). Identification of these climatically vulnerable species is necessary for conservation as well as indicating climate change in the study area. Climate change adaptation strategies for wildlife species require creating a link between an explicitly stated expectation from the changing global climate that could affect the species, their habitats and appropriate actions to address those impacts (Poiani et al., 2011). In order to conserve the threatened species, it is extremely important to determine the actions to focus on the specific species concerned. To understand what species are in threat and for prompt conservation actions against their extinction, it is hence necessary to assess vulnerability of species in the changing climate. Although there is currently no broad consensus in the scientific literature regarding species vulnerability, the general concept is accepted as an assessment of a species' exposure, sensitivity and adaptability in combination (Foden et al., 2013). Exposure is the extent of climate change and variation that the species encounters and is projected to encounter, sensitivity is the inability of the species to persist, as is, under changing climatic conditions and adaptability is the ability of the species to respond to changes in climate (Advani, 2014).

In Nepal, field studies have detected upward shifts in tree species along the treeline in Himalaya (Gaire et al., 2013, Shrestha and Devkota 2010, Suwal 2010, Vijay Prakash and Ansari 2009). Forests cover are also expected to expand in Tibetan Plateau upto 22% of the area (Ni 2003). Each and every species have different physiological tolerances and dispersal adaptations therefore, every individual in the natural community will respond to Climate change at different levels. Changes in habitat will directly affect faunal diversity, affecting habitat specialist groups which are very sensitive to changes occurring. Amphibians, butterflies, reptiles, some species of birds and some mammals require very specific habitat and environmental conditions which are very vulnerable to the changes induced by anthropogenic climate change. So, a better understanding of how species respond to ongoing anthropogenic climate change is crucial for assessing vulnerability and guiding efforts to avoid potentially severe biodiversity loss (Williams et al., 2008; Dawson et al., 2011).

Agricultural expansion, over-exploitation and introduction of invasive species have been some of the main drivers of biodiversity loss, but several lines of research suggest that climate change could become a prominent, if not leading cause of extinction over the coming century (Thomas et al., 2004), that could be either direct impacts on the species or through other various indirect drivers (IPCC, 2013; Mantyka-Pringle et al., 2012). Studies have shown how some species have already started to respond with recent climate shifts (Sinervo et al., 2010; Sheridan & Bickford., 2011; Ockendon et al., 2014; Auer & King, 2014) and there have been various attempts made in order to assess potential risks to the species found in our biodiversity in the coming decades (Chevin et al., 2010; Midgley et al., 2010; Chessman, 2013).

2.2 Methods

2.2.1 Sampling strategy

To make the data consistent with the previous survey, a similar size of grid was adopted for the monitoring in the field with certain modifications in the survey process within the grid to glean much detailed information (Fig.2). In an earlier year survey, approximately 7.7km transect was laid in the grid. Adjusted transect of this study covered core and edge habitat too. Also it covered representative habitats in the plot. Transects were laid following the human trails due to difficult geographical terrains. Due to lack of previous study camera trap location, the selection of sites were based on the most suitable

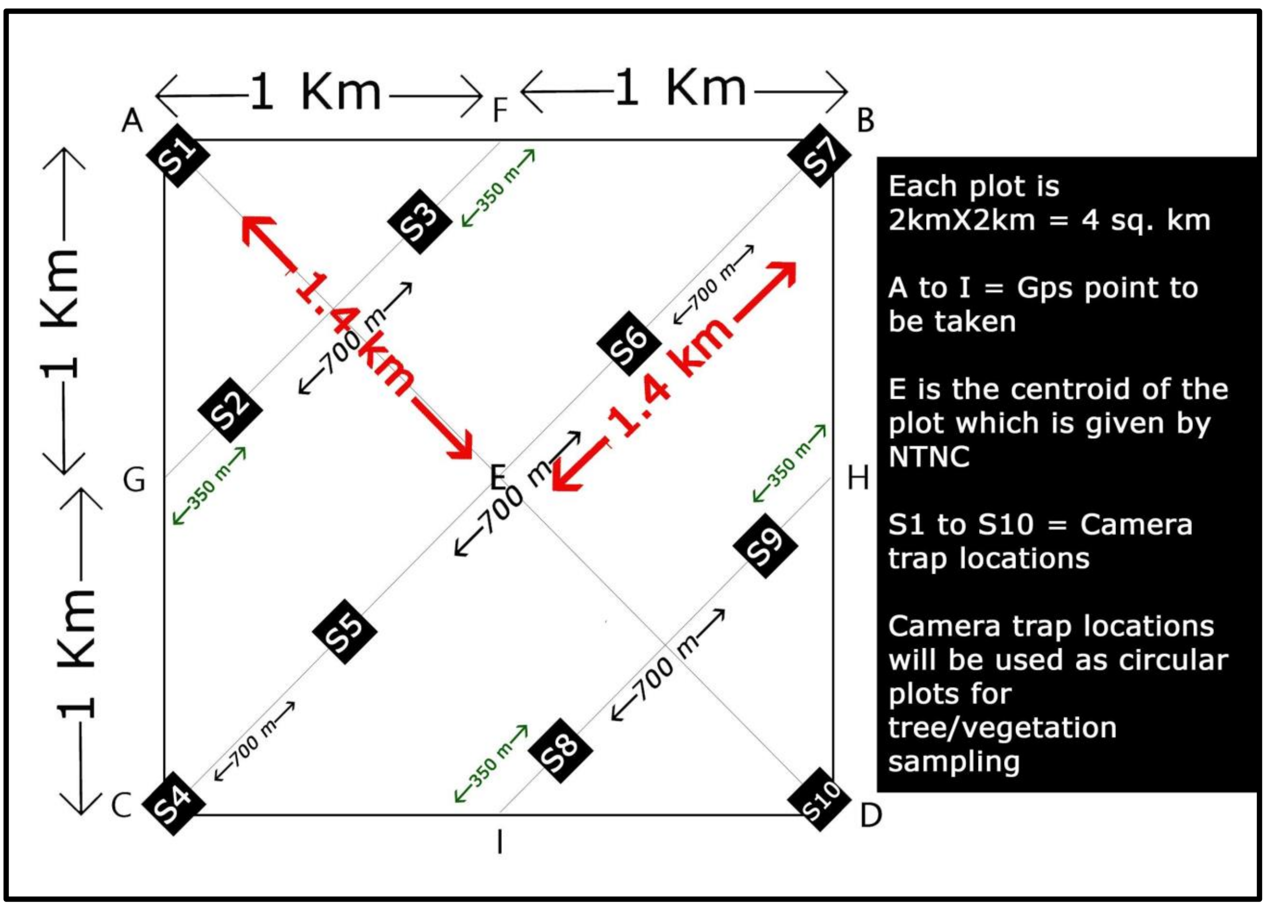


Figure 2: Hypothetical survey grid and transects, E represents edge and C represents Core

2.2.2 Equipment Used

Camera Trap (Mammals), Sherman Trap and TubeTrap (Small Mammals), Mist-net, Bat detector (Bats) Vernier caliper, gloves (Small mammals & bats), Binocular (Birds) Scoop net (Butterfly), DBH tape, quadrate tape (Plants), Camera (All), Compass, Measuring Tape (20m), Field Note Book, First Aid Kit.

Figure 3: Tube traps were used to study the small mammals

2.2.3. Mammals

2.2.3.a Transect

Within each monitoring grid, five systematic transects (between the range of 0.5 to 1km based on topographic features) were laid in different habitats (forests, grasslands, rangelands and water bodies) (Figure. 3). In each transect, animal sightings and indirect evidence like scats, pellets, droppings, faeces, dungs, pugmarks, scrapings, carcasses, feathers, quills and burrows were recorded. Apart from these, anthropogenic threats like signs of poaching and snaring, logging, grazing intensity, firewood and fodder collection were recorded in the transect. All the signs recorded in the grid were geo-referenced using GPS.

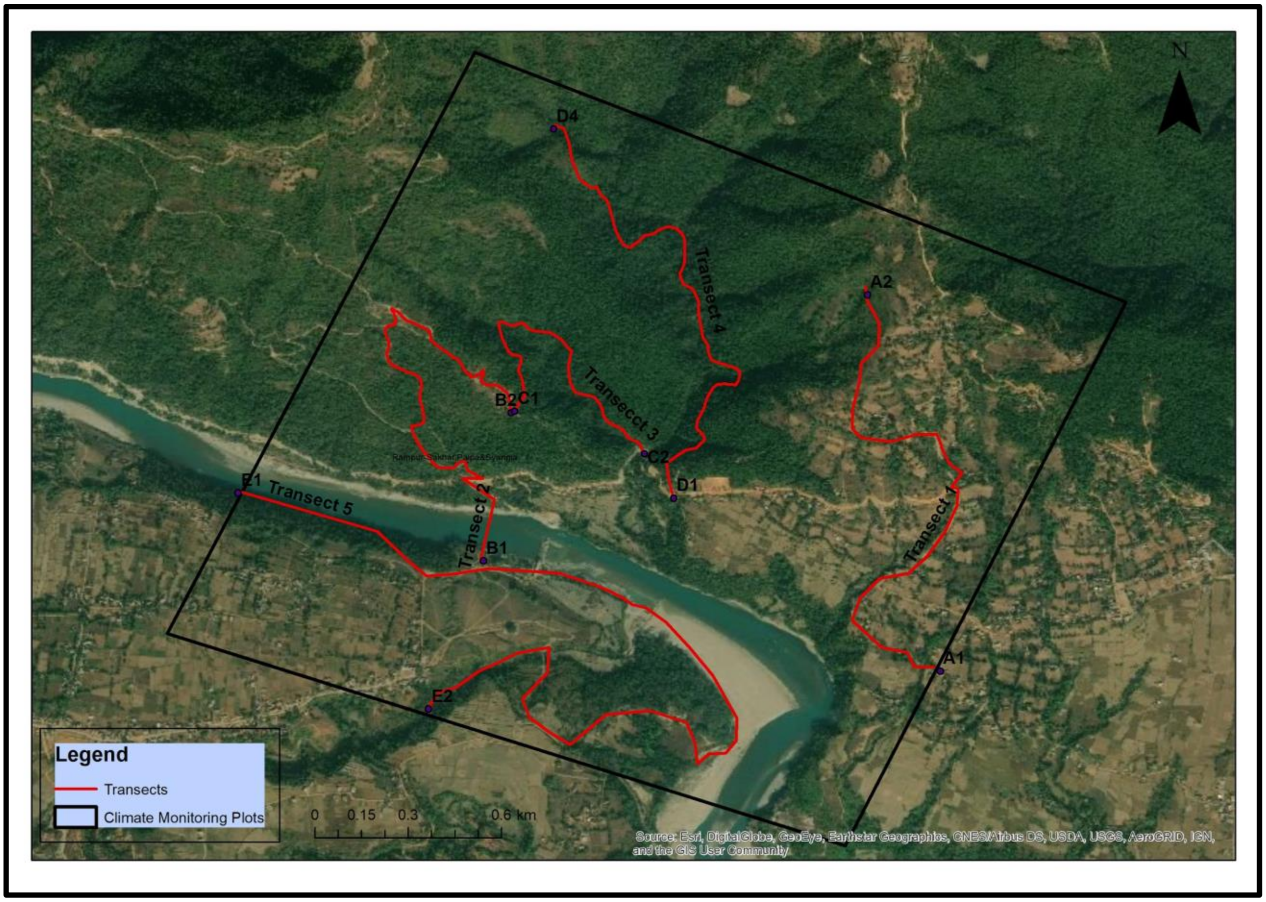


Figure 4: Study plot in Rampur showing the transect laid on the different habitats.

2.2.3.b Camera trapping

In each monitoring grids, ten camera traps were deployed for seven consecutive nights accounting a total of 70 camera traps night efforts. Camera stations were chosen based on different habitat types (forests, grasslands, human settlements, farmlands, gorges, rivulets, streams, river/banks etc.) by following the sampling strategy and frequent animal sightings and signs (Figure.4). Camera traps were set up adopting standard protocol (Karanth 1995) and were kept active 24 hrs a day to maximize photo captures. In few stations, camera traps were transferred to suitable locations if no animal captured for consecutive three days. Regular monitoring was done at each site to reduce the stolon of camera traps.


Figure 5: Camera trap installed in Titi focusing animal or human trail

2.2.3.c. Live Trapping

In each grid, 10 tube traps (https://bit.ly/3f2E2IA) and 10 Sherman traps (https://www.shermantraps.com/) were set up in the transect at least for three consecutive nights. The traps were set up 10m either side of the transect at the interval of 20m apart. Colorful flags were marked on the branches of trees at the trap stations to locate the traps. The traps were baited with a mixture of rolled oat porridge, peanut butter and cheese. Proper bedding (rolled dry grasses) was put inside the tube trap to reduce the death of small mammals due to excessive cold. Traps were monitored each morning and morphological measurements of captured individuals (weight, head-body length, tail length, hind foot length, ear length) and photographs were noted. All the species were identified using the mammals book (Baral and Shah 2008; Jnawali et al. 2011; Thapa et al. 2018).

Figure 6: Measurement of Himalayan Shrew, Tube shaped TubeTrap and Sherman's trap were used in surveying the small mammals

2.2.3.d. Visual Encounter survey and mist netting

Bats were surveyed using visual encounters in the roosts (caves, forests, old houses, tree holes, bamboo holes, banana leaves, rock crevices and other potential habitats) and mist nets (Figure 6). Possible mist netting stations were identified using direct observation and bat detectors. Mist Netting (9m and 6m) were installed at the possible site and the entrance of the cave for capturing cave dwelling bats from 1700hrs to 2000 hrs. Morphological measurements and photographs of captured individuals were taken and identified using field guide "Bats of Nepal"(Acharya et al. 2010.

Figure 7: Mist-net installed in the narrow gorge (Adhari khola) in the Rampur plot

2.2.4. Birds

Mackinnon's species richness counting method developed by Mackinnon and Phillips (1993) and described by Bibbyet. al. (2000) was implemented to record bird richness and diversity in each grid. The appropriate length of the list was between 8 and 20 species; the larger the likely total number of species at the site, the longer the length of list was chosen. Surveys were repeated until a minimum of five and preferably more than fifteen lists were produced for each grid (Mackinnon and Phillips 1993). Additionally, a list of all the bird frequencies were recorded throughout the survey on a daily basis. This method ensured the recordings of bird species that get excluded in Mackinnon's listing method. For raptors, flying long distances or having big home ranges, the highest number counted in one day was assumed to be the population.

For every bird making indistinct calls in the flock, the number of birds was estimated as one for every recording.

2.2.5. Herpetofauna

Five transects (100 x 10 m) were placed at least 500m apart in each grid. These transects were purposely plotted near the water sources (eg. streams, rivers, wetlands, ponds, dams, paddy fields, water bodies) and possible terrestrial habitats. Both amphibians and reptiles were searched during diurnal and nocturnal transects by time constrained visual encounter surveys (Heyer et al. 1994). Herpetofauna were searched in the transect for one hour using torch lights, walking at a slow pace at nights/days. Additionally, opportunistic species encountered besides the transects were also recorded. Morphological measurement and photographs of captured individuals were taken and identified using Schleich and Kästle (2002) and Shah and Tiwari (2004).

Figure 8: Amphibia monitoring at night in the small stream at Titi plot, Mustang

2.2.6. Butterfly

The line transects of 200-300m were established in the monitoring plots. Fixed point sampling was conducted in the interval of 100m for 10-15 minutes in each transect. These transects/points were laid in forests, forest edge, farmlands, grasslands, home gardens, water bodies etc. An ocular observation was adopted in the field and butterflies were captured using a scoop net (only when species identification needed) and released after taking photographs. Apart from that transect/point sampling, opportunistically encountered butterflies were also recorded and morphological measurements were also taken. Captured butterflies were identified using "Illustrated checklist of Nepal's Butterfly" (Smith 2011) and "A pocket book of Butterflies of Nepal" (Smith 1997).

Figure 8 An ocular observation was adopted in the field and butterflies were captured using a scoop net

2.2.7 Vegetation

Previously identified climate change indicator species of flora were monitored in each grid (WWF 2015). Information of the indicator species were conducted in the systematic random sampling based on forest types (dominant tree species) in the transect. Species diversity of trees were investigated in 10x10m plots established at an interval of 200m long transect of each site. Within each 10x10m plots, 5x5m and 1x1m plots were established to record saplings and seedlings respectively (Zobel et al. 1998). All tree species having DBH greater than 10 cm were taken into account within the plot.

Figure 9: Measurement DBH of tree species within 10x10m plots established plots.

2.2.7 Analysis

The camera trap images were sorted out, renamed according to the date and time till the seconds when those images were taken and categorized based on different species until the individuals of that species for each locations. After that the sorted out images were analyzed using different software of Camera Sweet program. Observational data of bids from the study plots were categorized based on the presence in binary form in excel and the occupancy model were fitted using the R2jags packages in R (R Development Core Team, 2012: Su and Yajima 2012) and JAGS (Plummer, 2003). Microsoft Excel was used to calculate the general analysis while ArcGIS 10.2 along with QGIS was used for the spatial analysis

2.3. Result and Discussion

2.3.1. Plot Information

2.3.1.a Plot 1: Chhonhup

Among all the plots, Chondup lies in the northernmost part of Mustang District, near the border with China, Korala. It is located 29.2876, 83.9206 (centroid) at the elevation 4770m in Lomanthang Rural Municipality. Chhondup represents the high mountain physiographic zone and falls under Western Himalayan alpine shrub and Meadows ecoregion (Figure 10). Lo Manthang can be accessed by a motorable track from Jomsom-Bhena. The plot represents an alpine grassland habitat and the entirety of the plot area is grassland in virtual plane setting, absolutely lacking tree and shrub species.

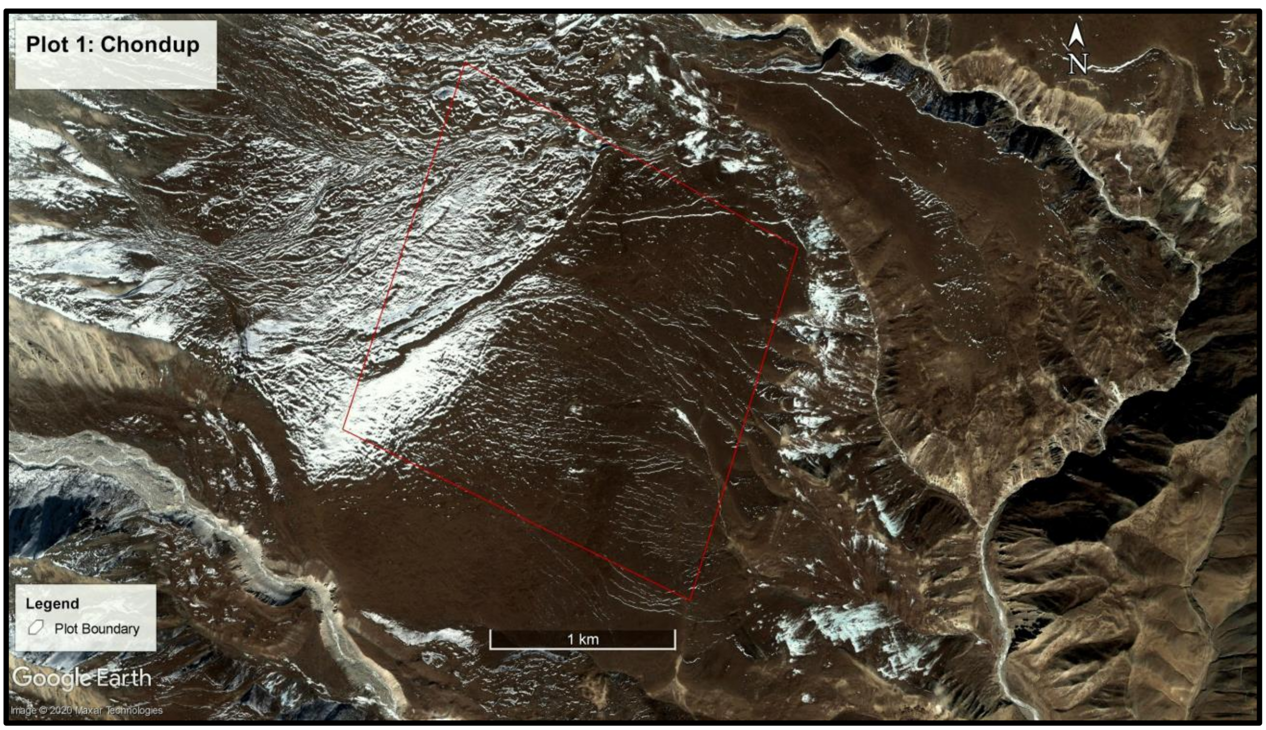


Figure 10: Monitoring plot boundary overlay in the Google earth image

a) Faunal diversity

Only three species of mammals, 17 species of birds, two species of butterflies and no herpetofaunal diversity was recorded from the plot. Altogether, 2617 photographs were captured from Chhonhup in the camera traps survey. However no any wildlife photographs were captured in the Camera trap survey and all the species were recorded by direct sighting or recorded using small mammals' traps (Table 2). Among the mammalian fauna, Woolly Hare *Lepus oiostolus* and Royle's Pika *Ochotona roylei* were sighted directly, while Fawn-colored Mouse *Mus cervicolor was* recorded from Sherman's traps. Fawn-coloured Mouse has an elevation range below 2000m asl (Aplin and Molur 2016) is recorded in 3993m asl might be the world highest elevation record for the species. Among these, Snow leopard *Panthera uncia* (recorded by NTNC 2016) is globally Vulnerable while Grey Wolf *Canis lupas* is nationally Critically Endangered species. Similarly Bearded Vulture *Gypaetus barbatus*, Himalayan Griffon *Gyps himalayensis* are globally Near Threatened species while they are categories as nationally Vulnerable species. Moreover, Himalayan Snowcock *Tetraogallus himalayensis* is a nationally Near Threatened species. Temperature in the Lomangthan drops below 0 degree celsius in the winter season. Data from 1982-2012 shows an average temperature of -1.1 degree on December, January and February in Lo-mangthan area (https://bit.ly/34HTEMJ) could be the reason behind lower the species diversity in the Chhophup area as many species undergo hibernation during this period.

b) Comparing and compiling Chhonhup data

Comparing and compiling data of Chhonhup with NTNC (2016), altogether 10 species of mammals (could be nine if pika species recorded by NTNC 2016 is Royle's Pika), 18 species of birds, six species of butterflies and one species of herpetofauna was recorded from Chhonhup in 2016 and 2019-2020 survey (Table 2). Among them one species of mammals i.e Woolly Hare and five species of birds (Bearded Vulture, Himalayan Griffon, Yellow-billed Chough, Red-billed Chough and Horned Lark) were common in both survey (Table 2). Lower the number of species in the Chhonhup in 2020 could be the climate factor as this survey was conducted in the winter season while NTNC 2016 survey was conducted in the summer season.

Table 2: Comparing the number of species diversity in Chhonhup plot with NTNC 2016

Plot (Chhonhup, Mustang)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF (2019-20)	3	17	2	0
NTNC (2016)	8	7	5	1
SMCRF+NTNC	9	18	6	1
Common Species in both survey	1	5	NA	NA

2.3.1.b Plot 2: Bhena

The plot is located in the boundary of Lo-mangthan and Barhagaun Mukti Kshetra rural Municipality of Upper Mustang District along the Jomsom-Kagbeni-Lomanthang Road. The plot lies 28.98414 83.81478 Midpoint), at an elevation ranging from 3500 m asl to nearly 4500 m asl. Bhena represents the high mountain physiographic zone and falls under Western Himalayan alpine shrub and Meadows ecoregion. Two types of trees (*Juniperus indica* and *Betula utilis*) have been reported from the plot (Alpine Consultancy 2015). This plot represents the only suitable area with relatively large extent of vegetation cover and fewer indications of grazing pressure by domestic livestock. The land cover type mostly consists of shrubland and some scattered grassland. A major perennial stream was known to drain the plot area into the Kaligandaki River, located near Bhena village.

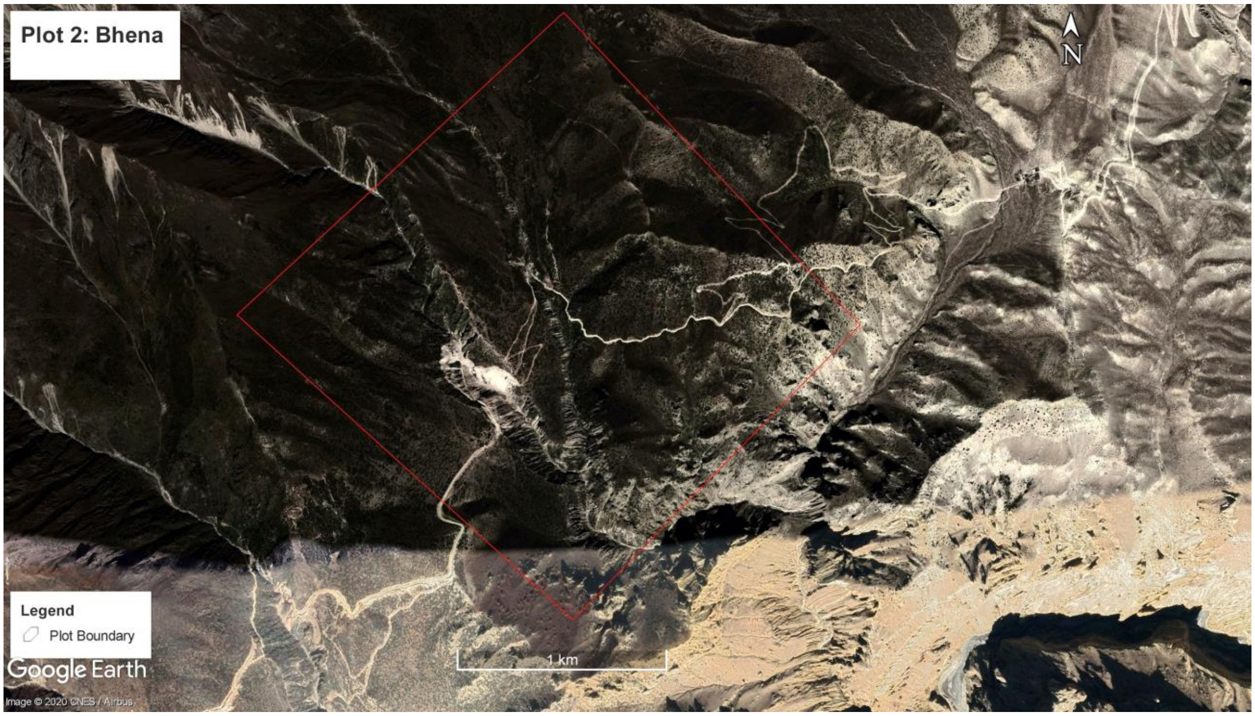


Figure 11: Monitoring plot boundary overlay in the Google earth image

a) Faunal Diversity

Altogether four species of mammals including the pugmark of Snow Leopard, 17 species of birds, only three species of butterflies and no herpetofauna was recorded from the site (Table 3). Among 18,003 photographs captured by the camera trapping no any mammals was captured in the survey. All the mammals were directly sighted except for the snow leopard. Pugmark and local confirmation confirmed the presence of Snow leopard in the area. Though the area is listed as a Biodiversity hotspot by NTNC itself, the lower sighting may be due to the lower temperature in the area added by the construction of road carried out during the survey period.

b) Comparing and compiling Bhena data

Table 3 Comparing and compiling data of Bhena with NTNC (2016)

Plot 2, (Bhena Mustang)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF (2019/20)	4	17	3	0
NTNC (2016)	2	15	9	0
SMCRF+NTNC	6	20	9	0
Common Species in both survey	0	5	NA	NA

As shown on the table above altogether six species of mammals, 20 species of birds and nine species of butterflies were recorded in both the year of 2016 and 2019-2020 (Table 3). Out of six recorded species of mammals, the Snow Leopard *Panthera uncia* is globally Vulnerable and nationally Endangered while Himalayan Griffon *Gyps himalayensis* is categorized as Vulnerable nationally. No any mammal's species were common in both survey while five species of birds (Chestnut-crowned Bush Warbler, Himalayan Griffon, Large-billed Crow, Red-billed Chough and White-throated Redstart) were common on both season (Table 3).

2.3.1.c Plot 3: Jomsom

The plot lies at 28.783774, 83.7608000 at an elevation of 3000m in the Trans-Himalayan region in Gharapjhong RM of Mustang District towards north of Jomsom Bajar. The plot represents a high mountain physiographic zone and lies under western Himalayan broadleaf forests ecoregion. can be accessed by an earthen road from district headquarter and is considered to represent climate resistant ecotone region of conifer forest, alpine scrub and grassland predominantly on the north and northeast facing slope (Figure 12). The land cover type of the plot consists mostly of shrubland and minimum forest area. No settlements and agricultural land are located inside the plot. The plot is extremely dry with no surface source of water.

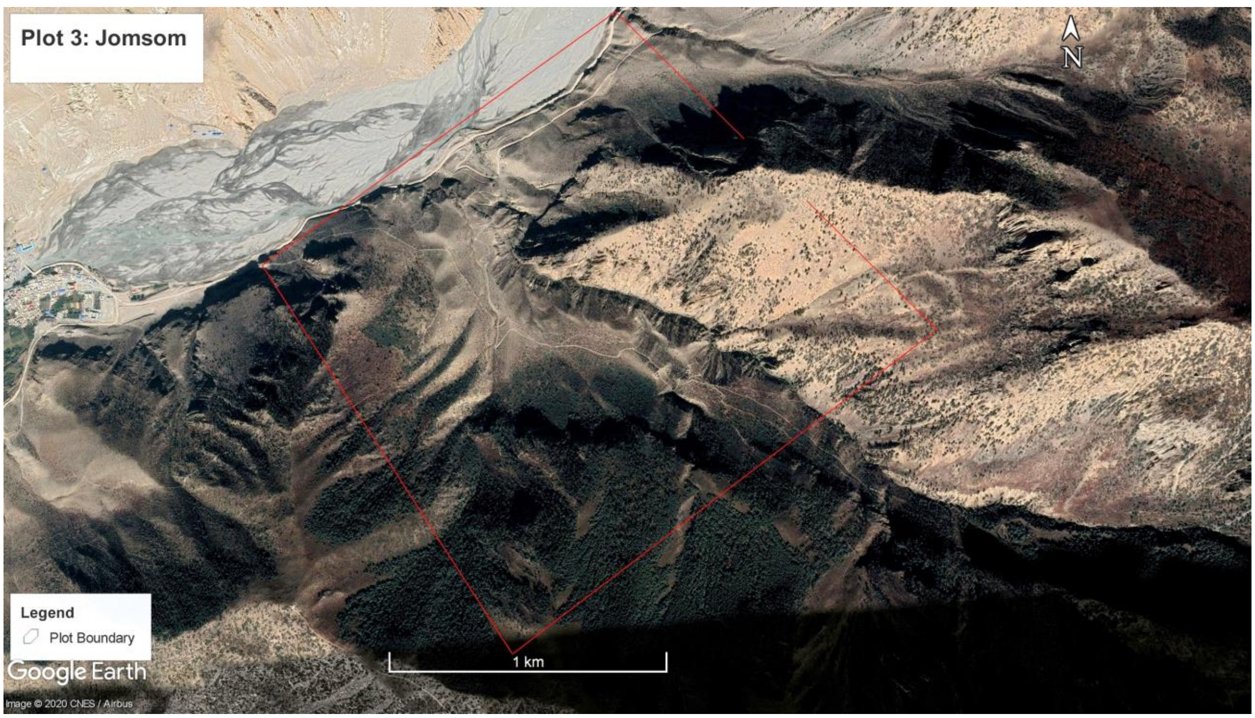


Figure 12: Monitoring plot boundary overlay in the Google earth image

a. *Faunal Diversity*

Five species of mammals, 14 species of birds and one butterfly were recorded from the Jomsom while no herpetofauna were recorded from the area (Table 4). Among the mammal species, three mammal species were recorded from TubeTrap and

Sherman's traps while among the 5450 photographs were captured, Leopard *Panthera pardus* and Red Fox *Vulpes vulpes* were recorded.

In the winter season, most of the species migrate to lower elevation in response to climate and food availability. Fewer numbers of species (comparing lower elevation plots) could be the reason behind the colder climate and less palatable grasses in the region. Winter, extremely dry areas could play a significant role in no record of herpetofauna in the area.

b. Comparing and compiling Jomsom data

Table 4 Comparing and compiling data of Jomsom, Mustang with NTNC (2016)

Plot 3 (Jomsom, Mustang)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	5	14	1	0
NTNC (2016)	6	10	5	0
SMCRF+NTNC	11	20	6	0
Common species in both survey	0	4	NA	NA

Altogether 11 species of mammals, 20 species of birds and six species of butterflies were recorded from the survey of 2016 and 2019-2020 (Table 4). Out of 11 species of mammals, Alpine Musk Deer *Moschus chrysogaster* globally as well as nationally endangered species, Leopard is globally as well as nationally Vulnerable species. Along the Climate Change monitoring, Leopard has been distributed from Barandabar area to Jomsom, though there were no records of Barking Deer *Muntiacus vaginalis* and Blue Sheep *Pseduois nayaur* in Jomsom during this survey period. Similarly, out of 20 species of birds, Egyptian Vulture *eophron percnopterus* is Endangered globally while it is Nationally Vulnerable species. Bearded Vulture

Gypaetus barbatus and Himalayan Griffon *Gyps himalayensis* are Near Threatened globally while Vulnerable nationally. Altogether four bird species (Bearded Vulture, Rock Bunting, Chukar and Large-billed Crow) and no any mammals species were common in both season (Table 4.)

2.3.1.d Plot 4: Kunjo

The plot lies at 28.65343, 83.61687, 2700m in the higher Himalayan region in Thasang Rural Municipality of Mustang District (former Kunjo VDC).This plot lies within the Annapurna Conservation Area. The plot represents the Western Himalayan broadleaf forests ecoreions (Figure 13). It can be accessed by a road from Lete along Beni-Jomsom Highway. A major portion of the land in the plot area is covered by forest. Around 15% of the area has been converted to agricultural land and settlement while 23% and 6% is represented by shrubland and grassland respectively. The plot lacks perennial streams and only seasonal streams are known to flow towards the west. While Titi Lake is included inside the plot, springs for water resources are also extremely rare.

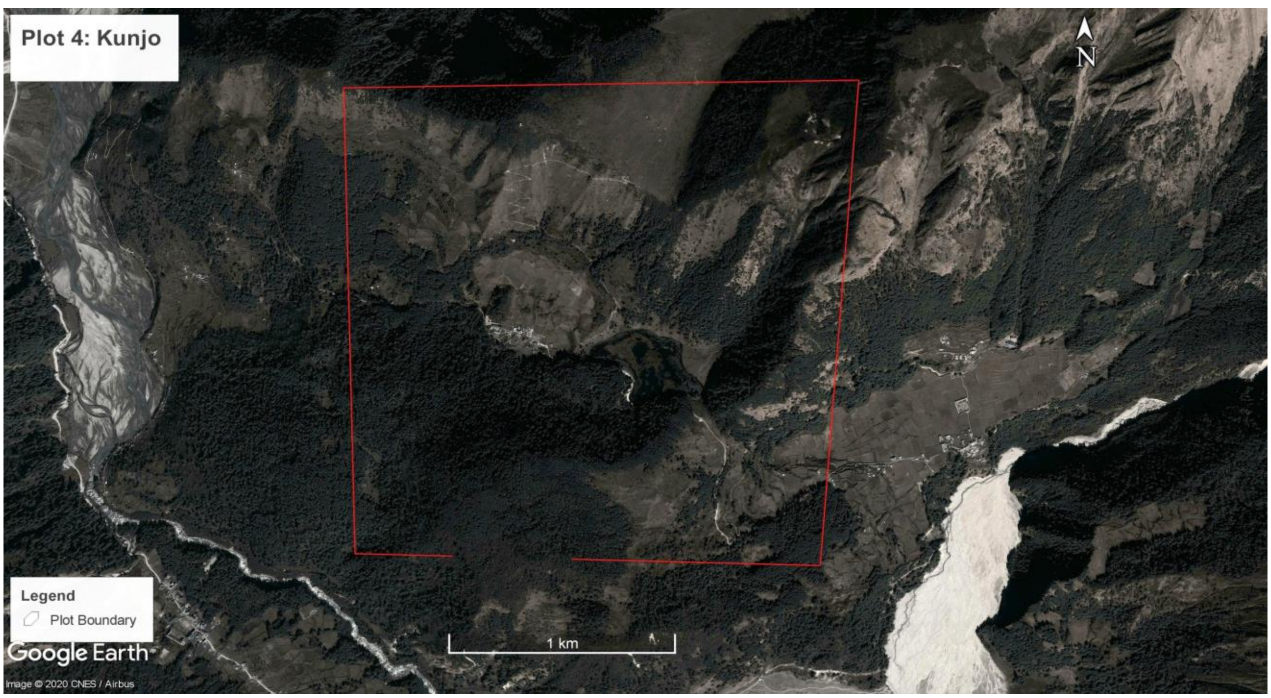


Figure 13: Monitoring plot boundary overlay in the Google earth image

a. Faunal Diversity

Seven species of mammals, 64 species of birds and 18 species of butterflies were recorded in the plot with no records of herpetofauna (Table 5). Altogether 626 photographs were captured from site in which four species of mammals, i.e., Leopard, Barking Deer and Himalayan Crestless Porcupine were recorded in camera traps while other mammals were confirmed by live trapping, sign survey and direct observation. Within the plot, pallets of Barking Deer are widespread along the sign of Leopard. Being a highly distributed species, Barking Deer is limited to Kunjo area with no record on upper CCM plots.

b. Comparing and compiling the Kunjo data

The survey conducted in the year 2016 and 2019/20 recorded 13 species of mammals, 86 species of birds, 25 species of butterflies and 3 species of herpetofauna (Table 85. Out of all the recorded mammal species Leopard is globally and nationally Vulnerable species while Barking Deer *Muntiacus vaginalis* nationally vulnerable species. Moreover, Himalayan Crestless Porcupine recorded in the plot is nationally Data Deficient species. Similarly, Cheer Pheasant *Catreus wallichii* is globally Vulnerable (VN) and nationally Endangered (EN) species while Himalayan Griffon is globally Near Threatened and nationally Vulnerable species and Golden Babbler *(Cyanoderma chrysaeum)* is Endangered nationally. Moreover Barking Deer was the only mammals species while eleven species of birds were common in both survey (Table 5).

Table 5 Comparing and compiling data of Kunjo, Mustang with NTNC (2016)

Plot 4 (Kunjo, Mustang)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	7	64	18	2
NTNC (2016)	7	30	15	1

SMCRF+NTNC	13	86	25	3
Common in both survey	1	11	NA	NA

2.3.1.e Plot 5: Narchyang

The plot lies at 28.52126124400 83.67415652140 1888m in the high mountain physiographic region in Annapurna Rural Municipality (Former- Narchyang VDC) of Myagdi District of Western Nepal. The plot represents the Western Himalayan broadleaf forests ecoregions. Blue Pine Forest and Temperate Broadleaf Forest are two types of forest system present in the plot (Figure 14). However at the lower elevation some subtropical species like Toona ciliata and Schima wallichii can be found (Alpine Consultancy 2015). A significant portion of the plot has been covered by shrubs and can be accessed by an earthen road from Guithe at Beni Jomsom Highway and a trek trail from Narchyang Besi. This is the only conveniently accessible large patch of remaining forest in the area, within this latitudinal belt. Part of the plot is already under agriculture, and there is a risk that these remaining forests could also become converted. Water source in the plot includes part of the Mristi River that drains into the Kaligandaki River within the same VDC. There are no other perennial streams within this plot and the people in the village use spring water for household purposes.

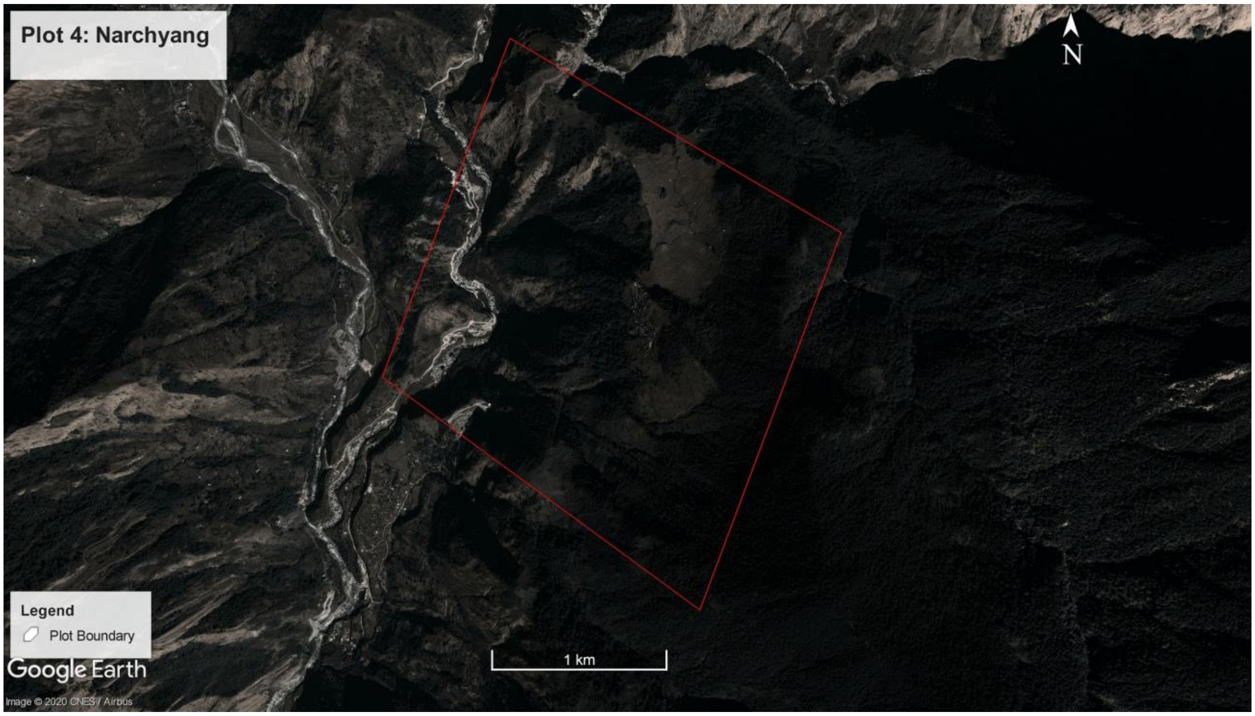


Figure 14: Monitoring plot boundary overlay in the Google earth image

a. Faunal Diversity

Twelve species of mammals, 67 species of birds and 22 species of butterflies were recorded from the plot. There were no sightings of herpetofauna on this site (Table 6). Among 860 photographs captured by Camera traps, five species of the mammals (Asiatic Black Bear, Barking Deer, Common Leopard, Large Indian Civet, and Leopard Cat) recorded in the plot were identified from camera traps while others were directly observed and confirmed from the sign survey. Himalayan Black Bear *Ursus thibetanus*, Leopard are globally vulnerable species while Himalayan Goral *Naemorhedus goral* is Near Threatened species recorded in the plot. Moreover, seven species of small mammals have been recorded from the plot. Cheer pheasant, range-restricted species recorded in the region is the only globally Vulnerable species.

b. Comparing and compiling Narchyang data

The survey conducted in 2016 and 2019/20 recorded 13 species of mammals, 77 species of birds, 26 species of butterflies and two species of herpetofauna in the

Narchyang plot (Table 6). Among the mammals, two species Barking Deer and Large Indian Civet and six species of birds (Common Kestrel, Great Barbet, Grey Treepie Large-billed Crow, Long-tailed Shrike and Oriental Turtle-Dove) were common in both survey (Table 6). Unlike the higher elevation plots, the plot consists of heterogeneous land use consisting of 31% is covered by forest, 22% by shrubs and 10% is grassland may be the reason behind higher diversity of mammalian species. Moreover records of seven species of mammals indicate that there are activities of the small mammals as the temperature was warmer than the Jomsom.

Table 6 Comparing and compiling data of Narchyang, Myagdi with NTNC (2016)

Plot 5 (Narchyang, Myagdi)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	13	67	22	0
NTNC	3	25	19	2
SMCRF+NTNC	14	77	26	2
Common species in both survey	2	6	NA	NA

2.3.1.f Plot 6: Chitre-Bhadaure

The plot lies at 28.2565 83.8129 1500m in the mid-hills, straddling the border between Kaski and Parbat District of Western Nepal. The plot lies in Annapurna Rural Municipality of Kaski and Modi Rural Municipality of Parbat district. The plot represents Middle Mountain and Himalayan subtropical pine forests. Subtropical broadleaf forest is the major forest type mainly consisting of Schima wallichii and Castanopsis indica associated with other species (Figure 15). A major portion of the land in the plot area is covered by forest and few has been converted to agricultural land and settlement. A number of perennial streams and springs originate in the forest and drain into the Modi River through a major tributary that traverses the plot. The plot can be accessed by a motorable track that joins at Kande along Pokhara-Baglung Highway and lies within Panchase protected forest.

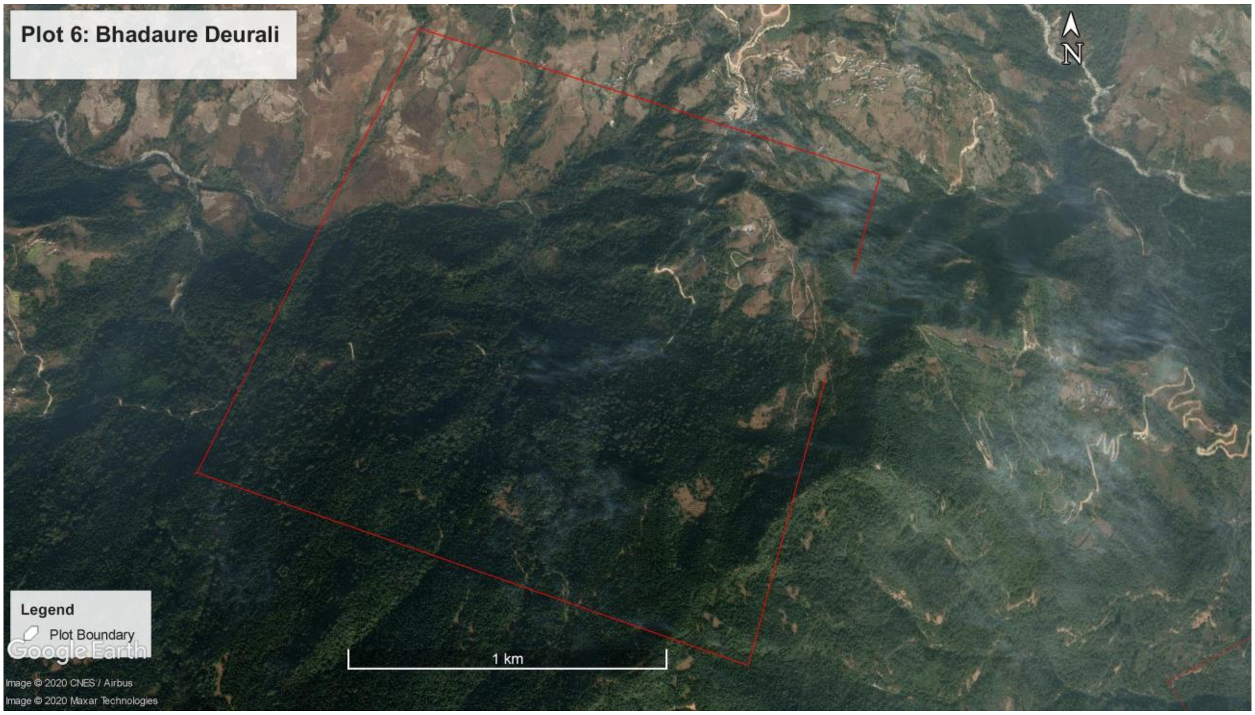


Figure 15: Monitoring plot boundary overlay in the google earth image

a. Faunal Diversity

Eleven species of mammals, 61 species of birds, 27 species of butterflies and two species of herpetofauna were recorded from the plot (Table 7). Among 677 photographs were captured from Bhadaure in camera trap, Five species of the mammals recorded while others were recorded from live trapping, direct observation and sign survey. Four species of small mammals and a bat species were recorded in the plot. Leopard is globally Vulnerable species and Assam Macaque *Macaca assamensis* is the Near Threatened species was recorded in the plot. Moreover, Red-headed Vulture *Sarcogyps calvus* is the globally Critically Endangered species recorded in the plot.

b. *Comparing and compiling Bhaduare-deurali data*

The survey conducted in 2016 and 2019/20 recorded a total of 12 species of mammals, 79 species of birds, 34 species of butterflies and six species of herpetofauna in the Narchyang plot (Table 12). Altogether three species of mammals (Assam Macaque, Barking Deer and Leopard) and fourteen species of birds were common in both survey (Table 12).

Table 7 Comparing and compiling data of Bhadaure Deurali, Parbat,Kaski with NTNC (2016)

Plot 6. (Bhadaure Deurali, Parbat,Kaski)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	11	61	27	2
NTNC	4	33	25	5
SMCRF+NTNC	12	74	34	6
Common species in both survey	3	14	NA	NA

2.3.1.g Plot 7: Harpankot

The plot lies at 28.240307 83.8500, 960m in the midhill physiographic region in the western part of Kaski District. The plot is situated within Pokhara-Lekhnath sub-metropolitan city (Former- Bhadaure Tamagi VDC) and represents Himalayan subtropical pine forests and Himalayan subtropical broadleaf forests ecoregion. Subtropical Broadleaf Forest consisting of *Schima wallichii* and *Castanopsis indica* forest are major forest types in the plot (Figure 16). This plot lies within Panchase protected forest in the major catchment of the Phewa Lake 71% of the plot area is covered by forest and around 19% of the plot has been converted into agricultural land and human settlement area. It can be accessed by a motorable track from Pokhara sub-metropolitan city. The major stream feeding the Phewa Lake is the Harpan Khola that flows across this plot. Perennial streams like the Rimale Khola, the Silibang Khola and the Sa Khola drain the plot area into the Harpan Khola.

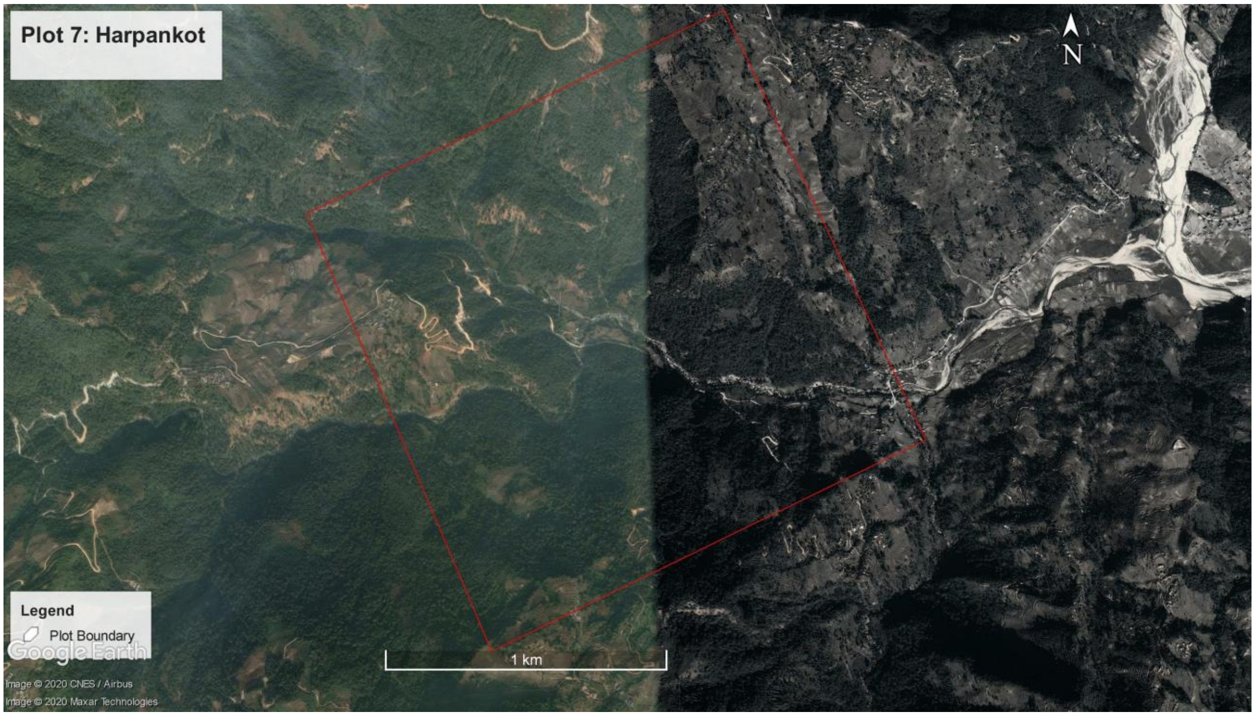


Figure 16: Monitoring plot boundary overlay in the google earth image

a. *Faunal Diversity*

Altogether 11 species of mammals, 65 species of birds, 24 species of Butterflies and 3 species of Hepretofauna were recorded from the plot (Table 14). Among the 1942 photographs recorded in camera traps, six of the individuals were captured from camera traps while others were confirmed by live trapping, sign survey as well as direct observation. Three species of small mammals have been recorded from the plot. In this plot, Leopard is globally vulnerable species while Large Indian Civet *Viverra zibetha* and Assam Macaque is globally Near Threatened species. No globally threatened avian species recorded in the plot although a 2016 NTNC survey recorded White-rumped Vulture *Gyps bengalensis*, a globally Critically Endangered species.

b. Comparing and compiling Harpankot data

Table 8 Comparing and compiling data of Harpankot, Kaski with NTNC (2016)

Plot 7 (Harpankot,Kaski)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	11	65	24	3
NTNC	4	43	71	3
SMCRF+NTNC	13	86	81	5
Common species in both survey	3	23	NA	NA

Altogether 13 species of mammals, 86 species of birds, 81 species of butterflies and five species of herpetofauna were recorded from 2016 and 2019/20. Among the total mammals three species of mammals (Large Indian Civet and Leopard Cat) and 23 species of birds are common in both survey (Table 8).

2.3.1.h Plot 8: Asardi-Malung

The plot lies at 27.91395, 83.66327 450m at midland physiographic region at the border between Syangja and Palpa District of Western Nepal covering southern parts of Galyang Municipality (Former Malung VDC) and northern part Rambha Rural Municipality (Former-Hungi VDC of Palpa District (Figure 17.). The plot represents Himalayan subtropical broadleaf forests, consisting of Tropical riverine Forest that includes *Acacia catechu* and *Bombax ceiba*, Sal Forest and Subtropical *Schima wallichii* Forest.

Figure 17: Monitoring plot boundary overlay in the google earth image

The major portion of the land in the plot area is covered by forest and around 25% has been converted to agricultural land and settlement. The Kaligandaki River flows across the plot and although there are no perennial streams draining the plot into the Kaligandaki River, there are few springs on the north facing slope of the plot. The plot can be accessed by the Siddhartha highway which passes through this plot and is considered to represent both climate vulnerable and climate resistant subtropical broadleaf forest distributed on south and north facing slopes of the Kaligandaki River Valley.

a. Faunal Diversity

Altogether 12 species of mammals, 81 species of birds, 21 species of butterflies and three species of herpetofauna were recorded from the plot (Table 16). Among 1493 photographs taken by the camera traps, five species were recorded and rest were recorded from live trapping, sign survey and direct observation. Four species were the small mammals in the plots. Leopard is only the globally Threatened species while Terai Grey Langur is the globally Near Threatened species. Moreover Steppe Eagle is the globally endangered species while River Lapwing and Himalayan Griffon is the globally Threatened species.

b. Comparing and compiling the data Asardi-Malung

Comparing and compiling data with NTNC, altogether 12 species of mammals, 108 species of birds and 91 species of butterflies and 13 species of herpetofauna were recorded from the survey of 2016 and 2019/20. Moreover five species of mammals (Barking Deer, Common Leopard, Jungle Cat, Leopard Cat and Terai Grey Langur) and thirty species of birds were common in both field survey (Table 9).

Table 9 Comparing and compiling data of Asardi-Malung, Palpa & Syangja with NTNC (2016)

Plot 8 (Asardi-Malung, Palpa Syangja)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	12	81	21	3
NTNC	5	57	85	12
SMCRF+NTNC	12	109	91	13
Common species in both survey	5	30	NA	NA

2.3.1.i Plot 9: Rampur

The plot is located at 27.88452, 83.90885, 390m elevation in the midland physiographic region at the border between Syangja and Palpa District of Western Nepal, covering southern parts of Chapakot Municipality (Former Sakhar VDC, Murtichaur) of Syangja District and northern part of Rampur Municipality (Tilakpur) of Palpa District. The plot represents Himalayan subtropical broadleaf forests having Tropical Riverine Forest that includes Acacia catechu and Bombax ceiba, Sal Forest and Subtropical Schima wallichii Forest (Figure 18).

Figure 18: Monitoring plot boundary overlay in the google earth image

A major portion of the land in the plot area has been converted to agricultural land and settlement. Only 40% of the plot has forests, with the rest covered with rivers, riverbanks, grasslands and human settlements. One of the major rivers of Nepal, the Kaligandaki River, flows across the plot, separating two districts. Two perennial tributaries drain the plot area into the river, one from Palpa side and another from Syangja side. These tributaries have been supplying water for irrigation in and around the plot area.The plot can be accessed by an earthen road from the district headquarter of Palpa and Syangja alike. This plot is considered to represent climate vulnerable subtropical broadleaf forest, a large portion of which consists of south and southeast facing slopes that are more vulnerable to climate change.

a. Faunal Diversity

Altogether 14 species of mammals, 93 species of birds and 28 species of butterflies and four species of herpetofauna were recorded from this site (Table 18). Among 1,592 images captured by camera traps, seven species of mammals were recorded from while rest species were recorded from live trapping, sign survey as well as direct observation. Six different species of small mammals were recorded from the plot. Among all the mammals, large Indian Civet and Common Bentwing Bat *Miniopterus schreibersii* are the globally Near Threatened species while Red-headed Vulture *Sarcogyps calvus* is Critically Endangered globally, Asian Woollyneck *Ciconia episcopus* globally Vulnerable while Himalayan Griffon *and* River Lapwing *Vanellus duvaucelii* are globally Near Threatened Species.

b. Comparing and compiling the Rampur data

Compiling the data of Rampur, Altogether 18 species of mammal, 138 bird species, 73 species of butterflies and 11 species of herpetofauna were recorded on combining both the surveys of 2016 and 2019/20 (Table 18). Two species of mammals (Large Indian Civet and Indian Hare) and 45 species of birds are common in both field survey (Table 10).

Table 10 Comparing and compiling data of Rampur-Sakhar, Palpa & Syangja with NTNC

Plot 9 (Rampur-Sakhar)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	14	93	28	4
NTNC	6	93	68	9
SMCRF+NTNC	15	138	73	11
Common species in both survey	2	45	NA	NA

<u>2.3.1.j Plot 10: Kabilas</u>

The plot is located at 27.78678524310 84.50937779380 1028m in the Churia physiographic region in the northern part of Chitwan District. The plot is situated at Bharatpur Metropolitan City (Former- Kabilas VDC) of Chitwan District. The plot lies in Himalayan Subtropical Pine forests ecoregion (Figure 19). The Plot represents Himalayan subtropical pine forests and Himalayan subtropical broadleaf forests. The major portion in the plot area is covered by thin forest and shrubland. The ridges on the north-facing slopes have been converted to agricultural land and settlement. The plot lacks perennial streams and only consists of some seasonal streams that flow towards the north. The area also has a problem of drinking water that has been sourced from Kaule, a village located miles away. It can be accessed by a motorable track from Bhorle at Muglin-Narayangarh Highway or a trek trail from Gajuri of Kabilas VDC.

Figure 19: Monitoring plot boundary overlay in the Google earth image

a. Faunal Diversity

Altogether, 12 species of mammals, 59 species of birds and 18 species of butterflies and one species of herpetofauna were recorded in this plot during the whole survey (Table 11.). Among the 1056 photographs taken by camera traps, six of the mammals were confirmed by camera traps while others were confirmed by direct observation, sign surveys and live trapping. Among all the species, Leopard is globally vulnerable species while Large Indian Civet and Tarai Gray Langur *Semnopithecus hector* a globally Near Threatened species also occurred in the plot. Himalayan Griffon, a globally Near Threatened bird species was also recorded in the plot. Considering the land use types, a major portion of the land has been covered by forest followed by shrubland and 5% grassland. Some 23% of the land, especially on the ridge and north-facing slopes has been converted to agricultural land and settlement. Moreover, The plot has elevation varies from 500 m asl to near 1100 m asl and supported two different types of forest, Subtropical Broadleaf Forest and Sal forest accompanied by the 84% covered by forest could be the reason behind great diversity of bird and mammals.

b. *Comparing and compiling the Rampur data*

Compiling the data with 2016 and 2019/20, altogether 17 species of mammals, 65 species of birds, 83 species of butterflies and 13 species of herpetofauna were recorded from the survey of 2016 and 2019/20. Among them one species of mammals ie. Jungle Cat and 30 species of birds were common in the both survey (Table 11).

Table 11 Comparing and compiling data of Kabilas, Chitwan with NTNC

Plot 10 (Kabilas, Chitwan)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	12	59	18	1
NTNC	6	39	83	13
SMCRF+NTNC	17	65	83	13
Common species in both survey	1	30	NA	NA

2.3.1.k Plot 11: Kaule-Shaktikhor

The plot lies at 27.77920, 84.60609 at the elevation of 1780m in the midland physiographic region in the northern part of Chitwan District. The plot is located in Ichhyakama Rural Municipality (Former Kaule and Dahakhani VDC) of Chitwan District and can be accessed by a trek, starting from Uperdang Gadi (Figure 20). The plot lies in Western Himalayan subalpine conifer forests ecoregion. The major forest type of the plot is Subtropical Broadleaf Forest consisting of Schima wallichii. At higher altitudes representation of temperate vegetation consisting of Oak and Rhododendron is found. Recent attempts have been made to connect the area by road through Shaktikhor and Chandi Bhanjyang, although the roads are still under construction. The plot has thick forest and almost less than 5% of the area has been converted to agricultural land and settlement. Moreover, the settlement has very scattered houses. The majority of the households have piped water supply systems for the drinking water. On an average about 69% households in the sampled area have been using piped water supply. There is however a lack of perennial streams and only seasonal streams were known to be present in the northern area where the slopes seemed moist in comparison to the dry steep of south facing slopes.

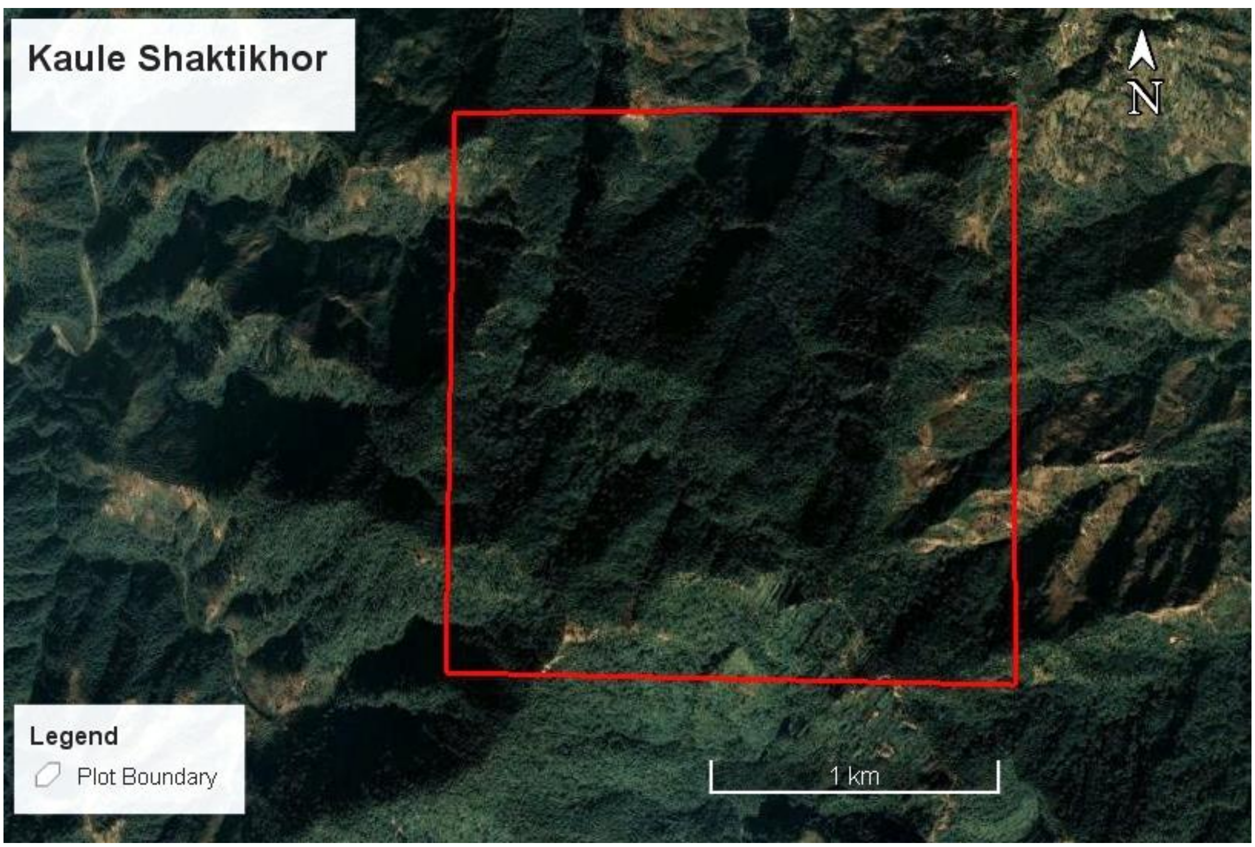


Figure 20: Monitoring plot boundary overlay in the google earth image

a. Faunal Diversity

Eleven species of mammals, 86 species of birds, 31 species of butterflies and 2 species of Herpetofauna were recorded inside the plot during the survey period (Table 13). Eight of the mammals were identified by Camera trapping while others were confirmed by direct observation and live trapping. Among the mammals, Large Indian Civet and Tarai Gray Langur is listed as Near Threatened globally in IUCN Redlist. Among the bird species Himalayan Griffon is only species listed globally Near Threatened. The elevation of the plots lies between 1000- 2000m elevation mostly over 1500m. More than 80% forest area was covered by the forest dominated by the *Schima wallichii.*

b. *Comparing and compiling the Rampur data*

Compiling the data of 2016 and 2019/20 data, 11 mammal species, 104 bird species, 39 species of butterflies and 16 herpetofauna were recorded in the plot combining both the surveys of 2016 and 2019/20 (Table 13). Only two mammal's species (Leopard Cat and Large Indian Civet) and 51 species of birds were common in both field survey (Table 12).

Table 12 Comparing and compiling data of Kaule-Shaktikhor, Chitwan with NTNC

Plot 11 (Kaule-Shaktikhor, Chitwan)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF (2020)	11	86	31	2
NTNC	2	67	36	15
SMCRF+NTNC	11	104	39	16
Common species of both survey	2	51	NA	NA

2.3.1.1 Plot 12: Barandabhar (Khorsor)

The plot lies at 27.5716 84.44277 205m in the Churia physiographic region in the Barandabhar Corridor Forest, north of Chitwan National Park. It lies in Bharatpur Metropolitan Municipality. The corridor connects Chitwan National Park and the northern forest habitats in CHAL (Figure 21). The plot can be accessed from the district headquarter of Chitwan by East-West highway and a concrete road to Badreni. Falling inside a protected area, the majority of the land is covered by forest trees, followed by shrublands, grasslands, river and sand. Two major forest types:Tropical Riverine Forest that includes *Trewia nudiflora* and Bombax ceiba and Sal Forest. The plot lies in Terai-Duar Savanna and Grassland Ecoregion representing high habitats for biodiversity. The Rapti River, that forms the northern border of Chitwan National Parks flows across the plot to the south, while two small perennial streams, Bhalu Kola and Thulo Ghol, are known to drain this plot into the Rapti River.

Figure 21: Monitoring plot boundary overlay in the google earth image

a. Faunal Diversity

Altogether, 14 species of mammals, 99 species of birds, 26 species of butterflies and 4 species of herpetofauna were recorded from the plot (Table 14). Among them most of the species were 13 confirmed through camera trapping and by direct observation and sign surveys. Among the mammals recorded, Asian Elephant *Elephas maximus*, Royal Bengal Tiger *Panthera tigris tigris* are listed as Globally Endangered species in IUCN Red List. Furthermore, One-horned Rhinoceros *Rhinoceros unicornis,* Sambar Deer *Rusa unicolor* and Sloth Bear *Melursus ursinus* are the mammals listed in globally Vulnerable species. Among the bird species, Asian Woollyneck, Great Hornbill *Buceros bicornis* and Lesser Adjutant *Leptoptilos javanicus* were enlisted globally Vulnerable in IUCN Red List whereas Alexandrine Parakeet *Psittacula eupatria*, Oriental Darter *Anhinga melanogaster* and River Lapwing *Vanellus duvaucelii* were the birds in Near Threatened globally in IUCN Red List. While among the four recorded herpetofauna, Gharial Crocodile *Gavialis gangeticus* is listed in Critically Endangered. While Mugger *Crocodylus palustris* and Indian Soft shell Turtle *Nilssonia gangetica* are enlisted in the Vulnerable category of IUCN red list. Located within the buffer and core zone of Chitwan National Park, the plot represents a mosaic of land use consisting of larger forest area, shrubland and grassland, which is the reason behind recording the highest diversity of mammals and birds. Moreover, the forest provides extension to the Chitwan National Park and at the same time connects it to northern habitats suggesting a good flow of species in the plot.

b. Comparing and comping the data of Barandabhar

Altogether 19 species of mammals, 120 species of birds and 36 species of butterflies and ten species of herpetofauna were recorded from the survey of 2016 and 2019/20(Table 13). Eight species of mammals and 44 species of birds are common in the both field survey.

Table 13 Comparing and compiling data of Barandabhar, Chitwan with NTNC

Plot 12 (Barandabhar,Chitwan)	Mammals	Birds	Butterfly	Herpetofauna
SMCRF	15	99	26	4
NTNC	13	69	30	7
SMCRF+NTNC	20	126	36	10
Common species of both survey	8	44	NA	NA

2.3.2. Overall Biodiversity list

Altogether 54 species of mammals representing nine orders and 23 families, 284 bird species represented by 20 orders and 66 families have been recorded from the monitoring plots. Moreover, 107 species of butterflies represented by one order and 7 families and 14 species of Herpetofauna represented by four orders and ten families were recorded from the study area (Table 14, Annex 1, Annex 2, Annex 9, Annex10).

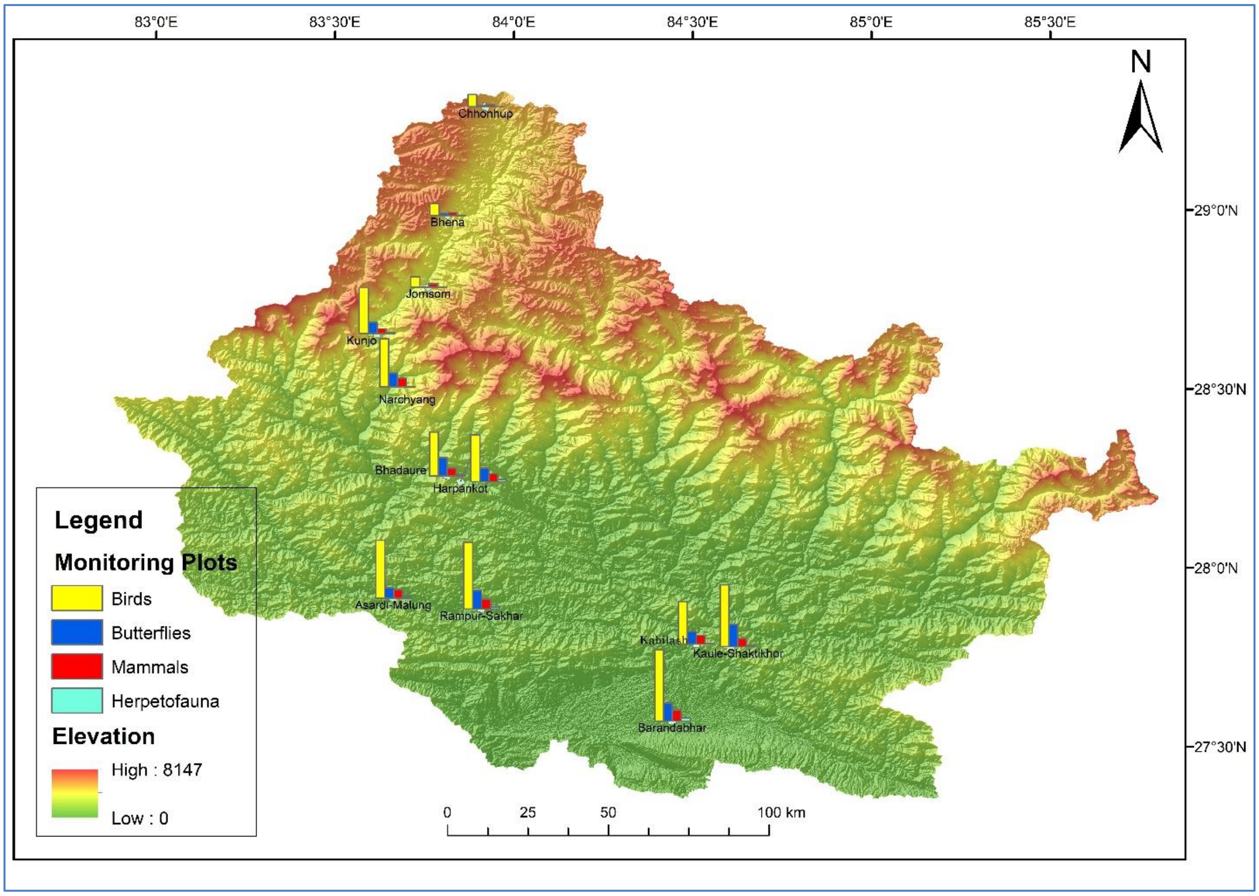


Table 14 Total number of species recorded in each plot

S.N.	Plots	Mammals	Birds	Butterfly	Herpetofauna
1	Chhondup	3	17	2	0
2	Bhena	4	17	3	0
3	Jomsom	5	14	0	0
4	Kunjo	7	64	16	2
5	Narchyang	12	67	19	0

6	Kaule-Shaktikhor	11	86	31	2
7	Bhadaure Deurali	11	61	25	2
8	Kabilas	12	59	17	1
9	Harpankot	11	65	19	3
10	Asardi-Malung	12	81	15	3
11	Rampur-Sakhar	14	93	26	3
12	Barandabhar	15	99	25	4

However, compiling the our survey with the NTNC 2016, altogether 77 species of mammals, 337 species of birds, 232 species of butterflies and 49 species of herpetofauna was recorded in the study area. Overall Plot wise comparison between mammals, birds and butterflies and herpetofauna with NTNC is shown in the table 15.

Table 15 Overall plot wise comparison of biodiversity

S. N.	Plots	Mammals			Birds			Butterflies			Herpetofauna		
		SMC RF	NT NC	Tot al	SMC RF	NT NC	Tot al	SMC RF	NT NC	Tot al	SMC RF	NT NC	Tot al
1	Chhondu p	3	8	10	17	7	18	2	5	6	0	1	1
2	Bhena	4	2	6	17	15	20	3	9	9	0	0	0
3	Jomsom	5	6	11	14	11	20	0	5	6	0	0	0
4	Kunjo	7	7	13	64	33	86	16	15	25	2	1	3
5	Narchya ng	12	3	13	67	25	77	19	19	26	0	2	2
6	Kaule-Shaktikh or	11	2	11	86	67	104	31	36	39	2	15	16
7	Bhadaur e Deurali	11	6	12	61	33	79	25	25	34	2	5	6
8	Kabilas	12	6	17	59	39	65	17	83	83	1	13	13

9	Harpankot	12	4	13	81	43	86	19	71	81	3	3	5
10	Asardi-Malung	12	5	12	81	57	108	15	85	91	3	12	13
11	Rampur-Sakhar	14	6	18	93	94	138	15	68	73	3	9	11
12	Barandabhar	14	13	20	99	69	126	25	30	36	4	7	10

2.3.3. Mammals

Altogether 54 species of mammals representing nine orders and 23 families have been recorded from the monitoring plot. Among them the highest number of species recorded in carnivora order represents 16 species, followed by order rodentia 15 species. Moreover, family muridae of order rodentia represent the highest number of species (10 species) which is followed by the felidae 5 species (Annex 5). Highest mammalian diversity was recorded from Rampur (15 species) followed by Barandabhar (14 species) and Asardi-malung, Kabilas and Narchyang (12 species each). In contrast, the monitoring plots located in the higher elevation Chooser-China Gate (plot1), Bhena-Chhuksang (plot 2), and Jomsom (plot 3) shows the lowest animal diversity with three, four and five species respectively. Altogether 32 species of mammals were recorded from camera trapping survey while remaining were recorded live Sherman's, TubeTrapping, Mist-netting as well as from direct observation. Moreover, Barking Deer and Leopard are the most distributed species which are distributed in seven monitoring stations each. The Barking Deer has been distributed from 200m to 3203 m as whereas Leopard mostly distributed 620m to 3139m asl in the elevation gradient. Moreover Golden Jackal *Canis aureus*, large Indian Civet, and leopard Cat *Prionailurus bengalensis* are distributed in 6 stations each (Figure 22).

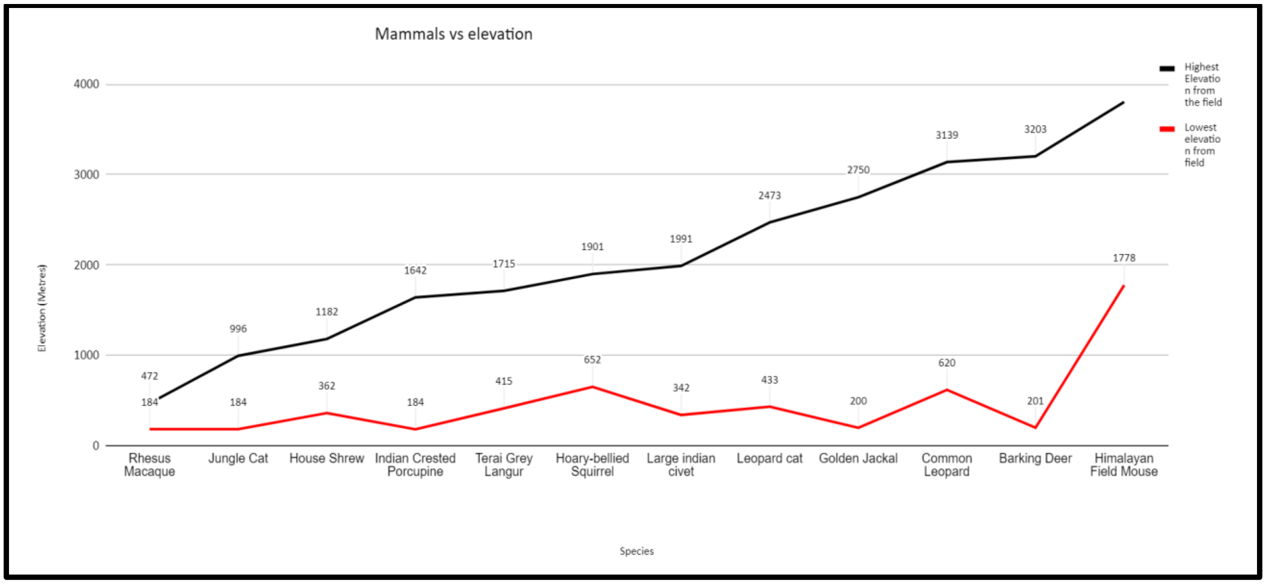


Figure 22: Mammals recorded against the elevation

2.3.3.a Mammals diversity in different zones

Species richness varies along the elevation gradient but not necessarily in the same way. As one metric of community structure, species richness is expected to decrease with increasing elevation (Sanders 2012), which can be attributed to the difference of species distribution and composition. Study area extended from elevation ranging from 200 m to 8091 m (Bista et al., 2017).

Elevation zone of CHAL area was shown in the figure below (Figure 23). During our study, Elevation Gradient up to 500 m was found to be highest with 31 mammals' species. This was followed by 1500-2500m elevation gradient with 18 mammals. Lowest numbers of mammals (2) were recorded in 4500-6000m elevation gradient. Highest recorded species was Barking deer (N=8) in different elevation gradients followed by Leopard Cat, Leopard and Golden Jackal (N=5).

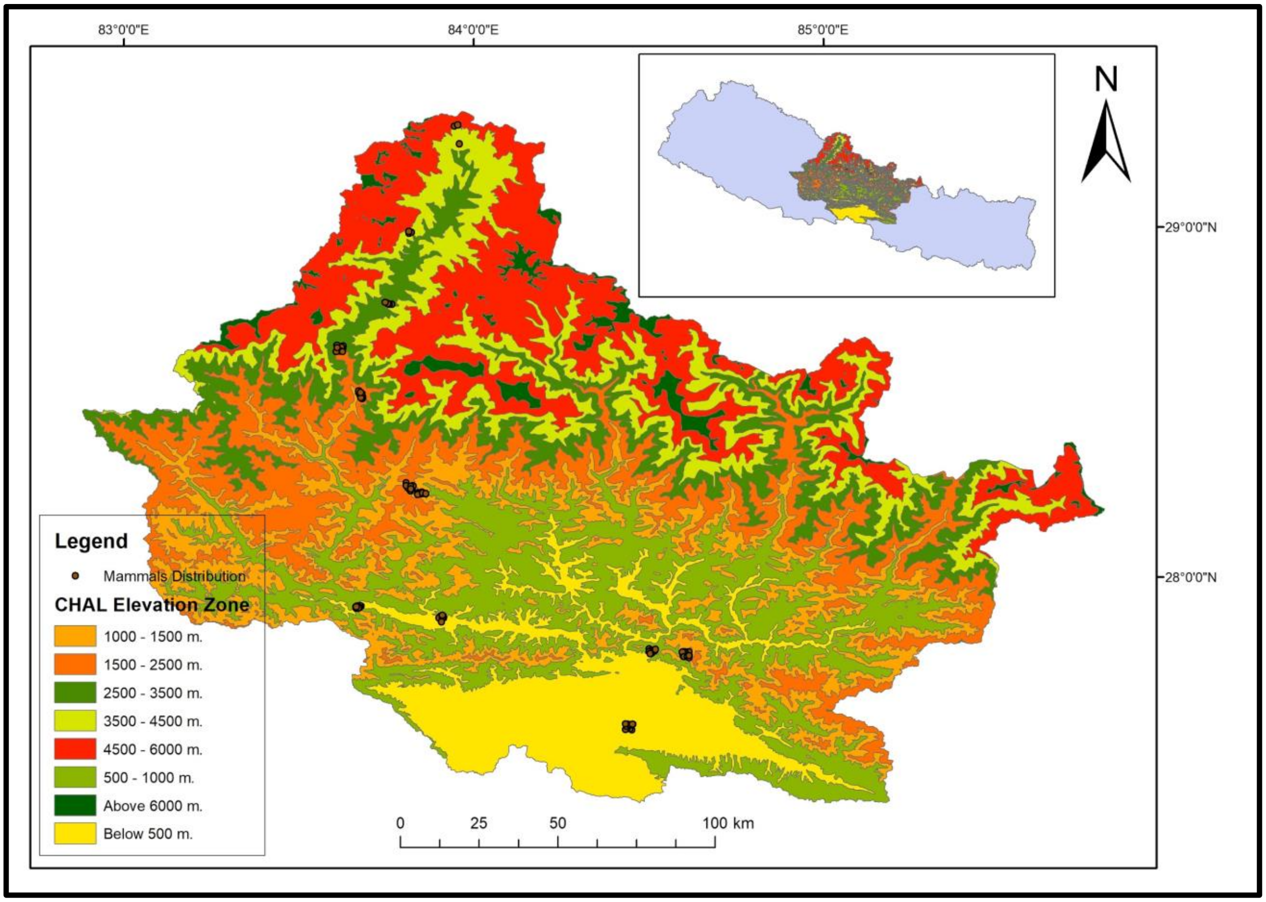


Figure 23: Map of mammals distribution against CHAL elevation zone

Altogether the study area covered four physiological regions of Nepal, High Mountains, Middle Mountain, Hills and Siwalik (Figure 24). During our study, among the four physiological divisions Hills was found to be highest in Mammals diversity (32) followed by High Mountains (17) Whereas, Middle Mountains and Siwalik were found with low mammal sightings (13). Barking Deer was the most sighted mammal in all four physiological divisions followed by Leopard, which was sighted in three physiological divisions except in the Siwalik region (Annex 2).

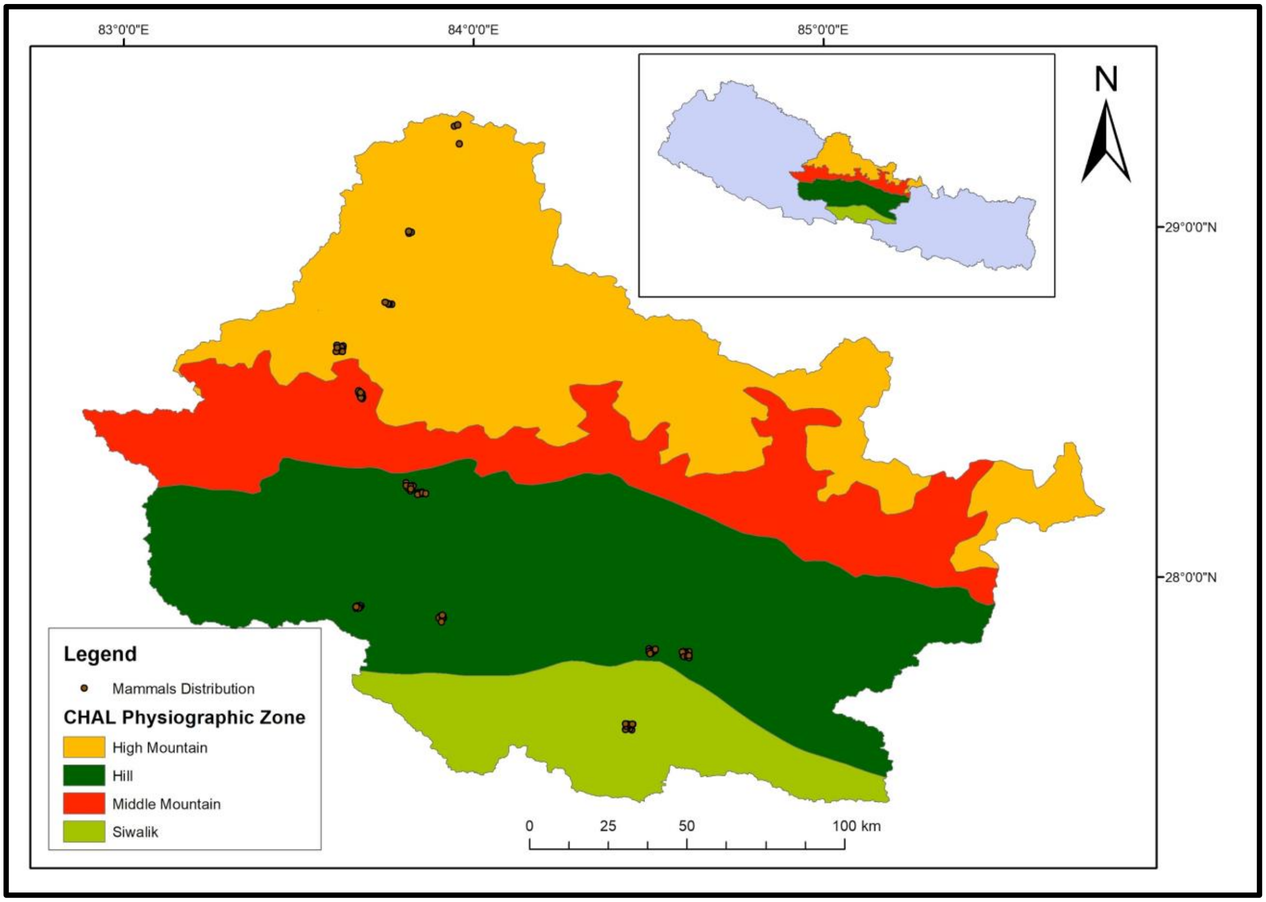


Figure 24: Map of mammals distribution against CHAL physiographic zone

Altogether, there are 867 terrestrial ecoregions, classified into 14 different biomes such as forests, grasslands, or deserts (Olson et al. 2001). A total of 10 ecoregions have been identified in the CHAL. Among them, monitoring plots represents six type of ecoregions 1) Eastern Himalayan alpine shrub and meadows, 2) Himalayan subtropical broadleaf forests 3) Himalayan subtropical pine forests 4) Terai-Duar savanna and grasslands 5) Western Himalayan alpine shrub and Meadows 6) Western Himalayan broadleaf forests (Figure 25).

Among all, Himalayan Subtropical pine forest represent most species (N=23) followed by Himalayan subtropical broadleaf forest (N=22) while Eastern Himalayan alpine shrubs and meadows represent only two species. Himalayan subtropical pine forest and Himalayan subtropical broadleaf forest represented by four plots each in the study area could be the region for higher number of mammalian species. However based on the number of plots representing an area Terai-Duar savanna and grasslands represented by a single plot consisting of 15 species was the best ecoregion for the mammals species. Similarly, Barking Deer represent most ecozone (N=4) followed by the Golden Jackal (N=3). Moreover 34 species represent only single ecoregion in the CHAL area (Annex 3).

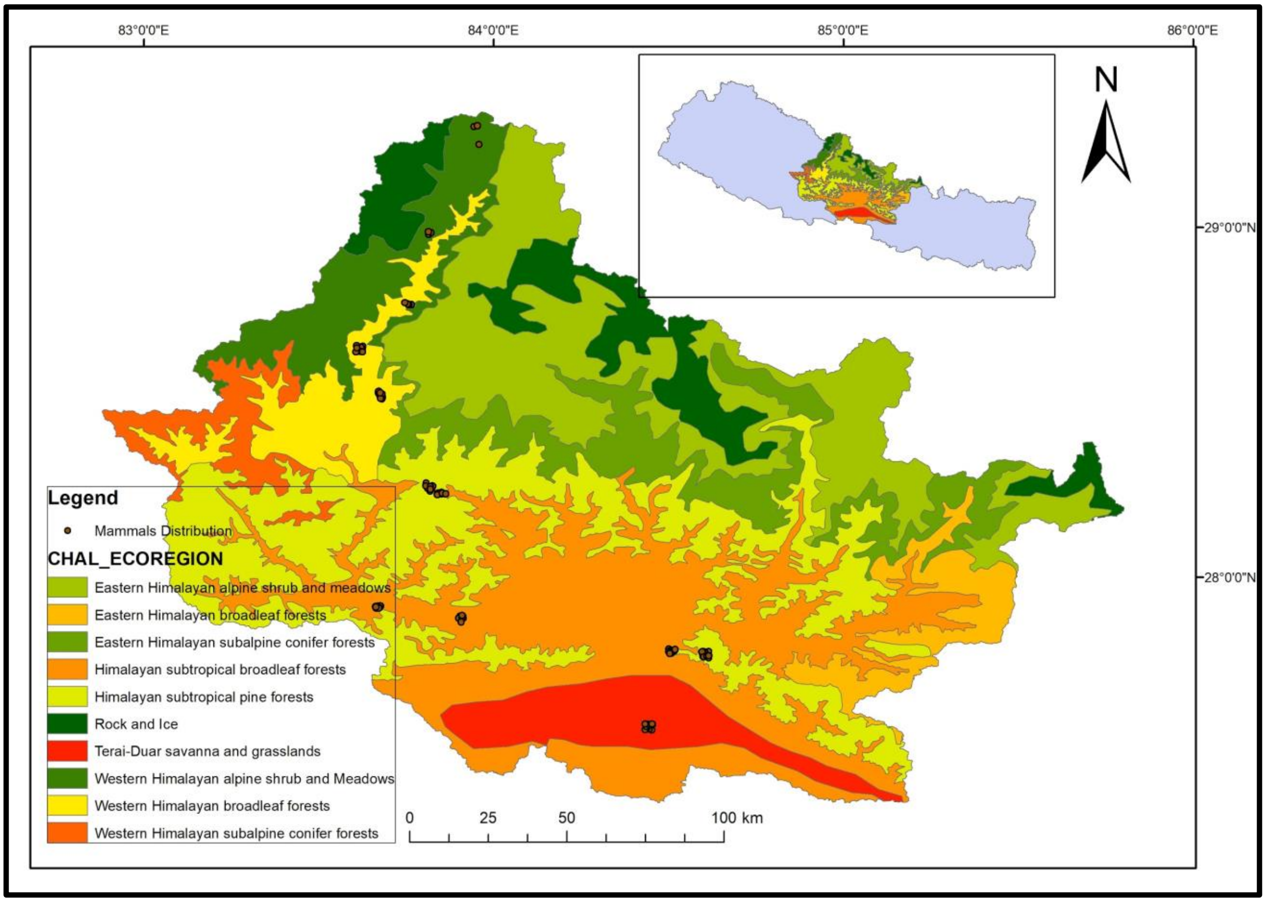


Figure 25: Mammal's distribution against CHAL ecoregion

2.3.3.b IUCN and National Status

Altogether seven species of mammals are listed in IUCN Global threatened list among them Royal Bengal Tiger and Asian Elephant are Endangered (EN) species while remaining five species are Vulnerable (VU). Similarly, 12 species are listed in National IUCN Red List category among them six species Snow leopard, Himalayan Black Bear, One-horned Rhinoceros and Royal Bengal Tiger, Sloth Bear and Asian Elephant are in Endangered category while remaining six species are nationally Vulnerable (Table 15). Moreover, five species (Himalayan Goral, Assam Macaque, Large Indian Civet, Terai Grey langur and Common Bentwing Bat) are globally near-threatened species and Ward's Field Mouse is globally Data Deficient species. Moreover, Himalayan Goral and Large Indian Civet is nationally Near-threatened and Red Fox, Himalayan Crestless Porcupine and Indian Crested Porcupine are national data deficient species.

Table 16: IUCN Global and national status of mammals recorded in permanent plots

S.N.	Common Name	Scientific Name	IUCN	National
1	Snow Leopard	*Panthera uncia*	VU	EN
2	Leopard	*Panthera pardus*	VU	VU
3	Barking Deer	*Muntiacus vaginalis*	LC	VU
4	Himalayan Black Bear	*Ursus thibetanus*	VU	EN
5	Leopard Cat	*Prionailurus bengalensis*	LC	VU
6	Assam Macaque	*Macaca assamensis*	NT	VU
7	Crab-Eating Mongoose	*Herpestes urva*	LC	VU
8	One Horned-Rhinoceros	*Rhinoceros unicornis*	VU	EN
9	Spotted Deer	*Axis axis*	LC	VU
10	Royal Bengal Tiger	*Panthera tigris*	EN	EN
11	Sloth Bear	*Melursus ursinus*	VU	EN
12	Asian Elephant	*Elephas Maximus*	EN	EN

2.3.4. Birds

2.3.4.a Diversity

Altogether 284 bird species represented by 20 order and 66 families have been recorded from the monitoring plots. Among them the highest number of species recorded in Passeriformes order representing 179 species followed by Accipitriformes and Piciformes having 15 species of birds each. Similarly, Muscicapidae family of order Passeriformes and accipitriformes family of order accipitriformes represent highest recorded family with 25 and 15 species respectively, In contrast, order Apodiformes represented by the single species is the lowest number of species in the plot (Annex 6). Highest bird diversity was recorded from Barandabhar (99 species) followed Rampur (93 species). However, the monitoring plots located in the higher altitude Jomsom, Bhena and Chhondup represented the lowest number of species diversity with 14, 17, 17 species respectively (Annex 5).

Among the bird species, 66% bird (187 species) are forest depended followed by the wetland 14% (39 species) (Annex 7). Moreover, Black-lored Tit was the most distributed species recorded in ten monitoring stations each followed by Himalayan Griffon and Large-billed Crow in nine monitoring stations. Similarly Common Coot was most individuals (268 individuals) followed by Rock Pigeon (117) and Himalayan Griffon (100 individuals) recorded in the entire field survey.

2.3.4.b IUCN and National Status

Eight species recorded in the climate monitoring plots are globally threatened. Among them Red-headed Vulture and White-rumped Vulture is Critically Endangered and Egyptian Vulture, Steppe Eagle are globally Endangered species. Moreover, four species (Cheer Pheasant, Lesser Adjutant, Great Hornbill and Asian Woollyneck) are in the globally Vulnerable category. Similarly, 16 species are in nationally threatened categories in which Grey-headed Fish Eagle is nationally critically endangered species while White-rumped Vulture Cheer Pheasant, Golden Babbler, Red-headed Vulture and Great Hornbill are nationally Endangered species (Table 16).

Table 17: IUCN Global and national status of birds recorded in permanent plots

S.N	Common Name	*Scientific Name*	National Status	Global Status
1	Bearded Vulture	*Gypaetus barbatus*	VU	NT
2	Himalayan Griffon	*Gyps himalayensis*	VU	NT
3	Golden Eagle	*Aquila chrysaetos*	VU	LC
4	Egyptian Vulture	*Neophron percnopterus*	VU	EN
5	Cheer Pheasant	*Catreus wallichii*	EN	VU
6	Golden Babbler	*Cyanoderma chrysaeum*	EN	LC
7	Slender-billed Scimitar Babbler	*Pomatorhinus superciliaris*	VU	LC
8	Steppe Eagle	*Aquila nipalensis*	VU	EN
9	Red-headed Vulture	*Sarcogyps calvus*	EN	CR
10	Lesser Adjutant	*Leptoptilos javanicus*	VU	VU
11	Grey-headed Fish Eagle	*Icthyophaga ichthyaetus*	CR	NT
12	Asian Openbill	*Anastomus oscitans*	VU	LC
13	Cotton Pygmy-goose	*Pseudibis papillosa*	VU	LC
14	Great Hornbill	*Buceros bicornis*	EN	VU
15	White-rumped Vulture	*Gyps bengalensis*	CR	CR
16	Asian Woollyneck	*Ciconia episcopus*	VU	VU

2.3.5. Butterflies

2.3.5.a Diversity

Altogether 107 species of butterflies representing one order and 7 families of Butterflies recorded from the current field survey (Annex 9). Among them, the highest number of species was represented by family *Nymphlidae* (54 species) followed by *Lycanidae* (20 species) and *Pieridae* (18 species) respectively. While the lowest number of species were represented by *Papilionidae* and *Herpsinidae* (three species each). In the entire survey, three species were unidentified. Highest number of butterflies were recorded from Kaule-Shaktikhor Plot (32 species) followed by Bhadaure Deurali (27 species). Chonndup, Bhena were the plot with lowest number of butterflies i.e. 2, 3 respectively whereas no species recorded in the Chhondup plot. Furthermore, most occurred species during the study was Painted Lady, which was recorded in 8 plots followed by Indian Tortoise Shell, Pale Grass Blue, Indian Admiral and Chocolate Pansy occurring each of them in 6 plots each.

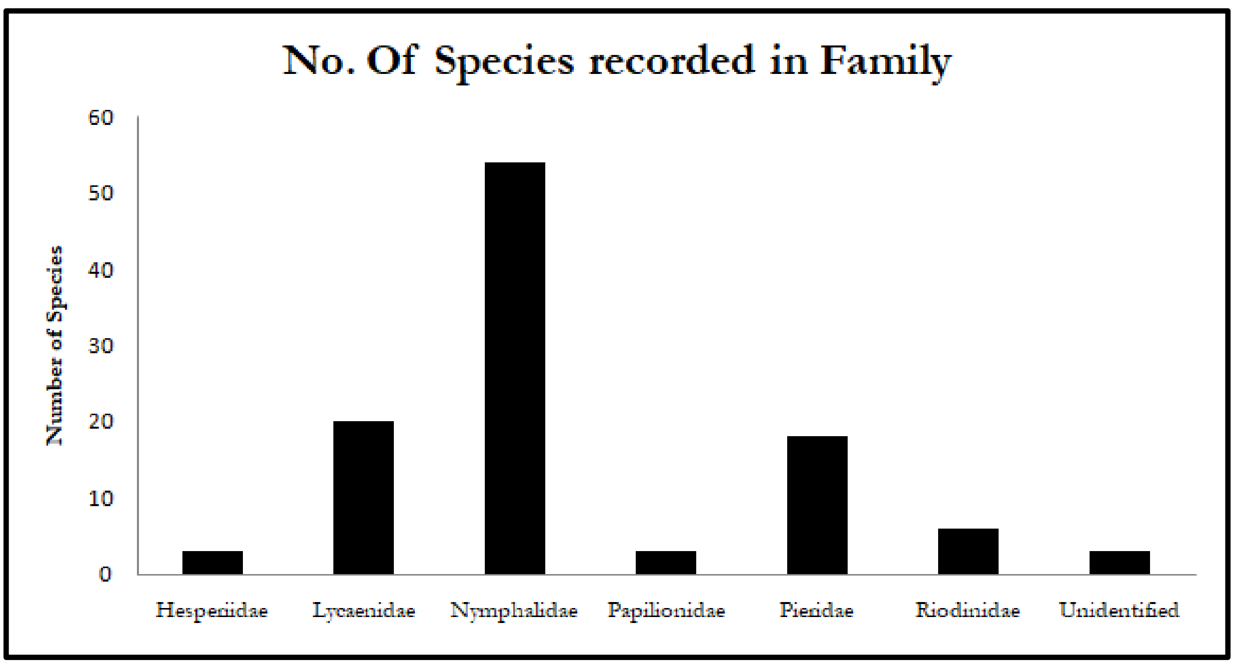


Figure 26: Number of species in Family

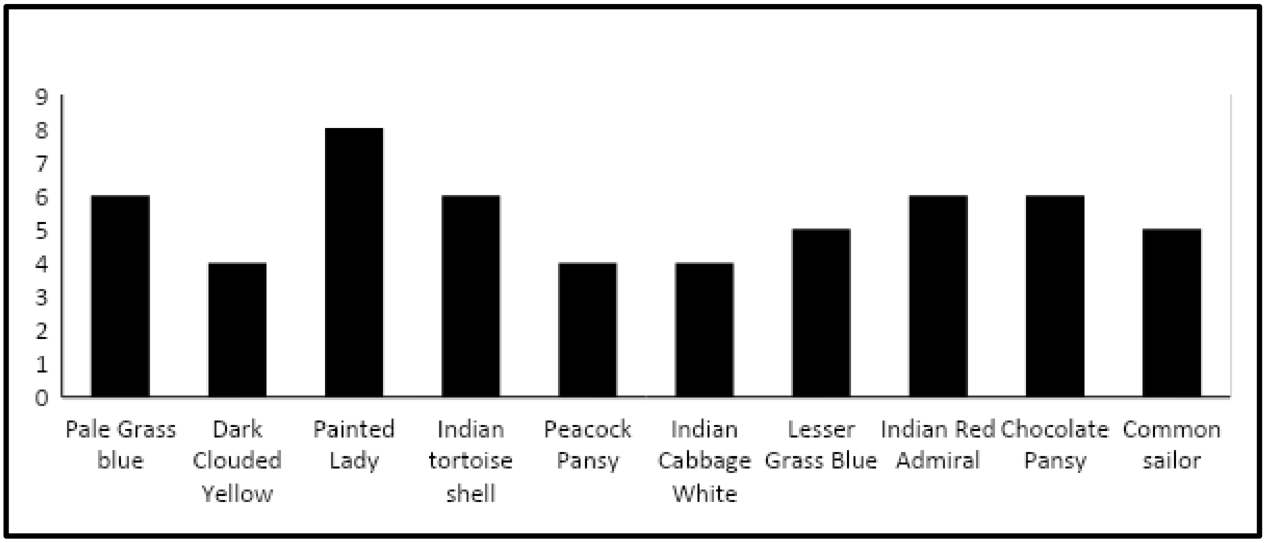


Figure 27: Most occurring butterflies species in the CHAL

2.3.6. Herpetofauna

Altogether 13 species of herpetofauna were recorded from the entire field (Annex 10). Among them five species belong to amphibia, eight species belong to reptiles. Among them order Anura represents the most number of species, followed by order Squamata. Similarly family Dicroglossidae represented by the most species (N=4) in the entire survey. Highest number of species was recorded in the Ramour site and none of the species was recorded in the upper three plots. Moreover, Gharial, Gavialis gangeticus is Critically Endangered species while Mugger *Crocodylus palustris* and Indian softshell turtle *Nilssonia gangetica* are globally Vulnerable species (Annex 11).

2.3.7 Elevation effect on the diversity of mammals, birds and butterflies

Our current survey on diversity of mammalian species along the elevational gradient pattern shows that animal diversity tends to increase with decrease in the elevation. Fewer species were recorded (3-7 species) in the high mountain (above 2700m asl), but species diversity increases gradually although fluctuates from Kunjo to Harpankot in hills and lower mountain (900-2700m) keeping species between 11-12 , however as the elevation decreases, species diversity increases till reaching the lower elevation, peaking at Barandabar (Figure 28).

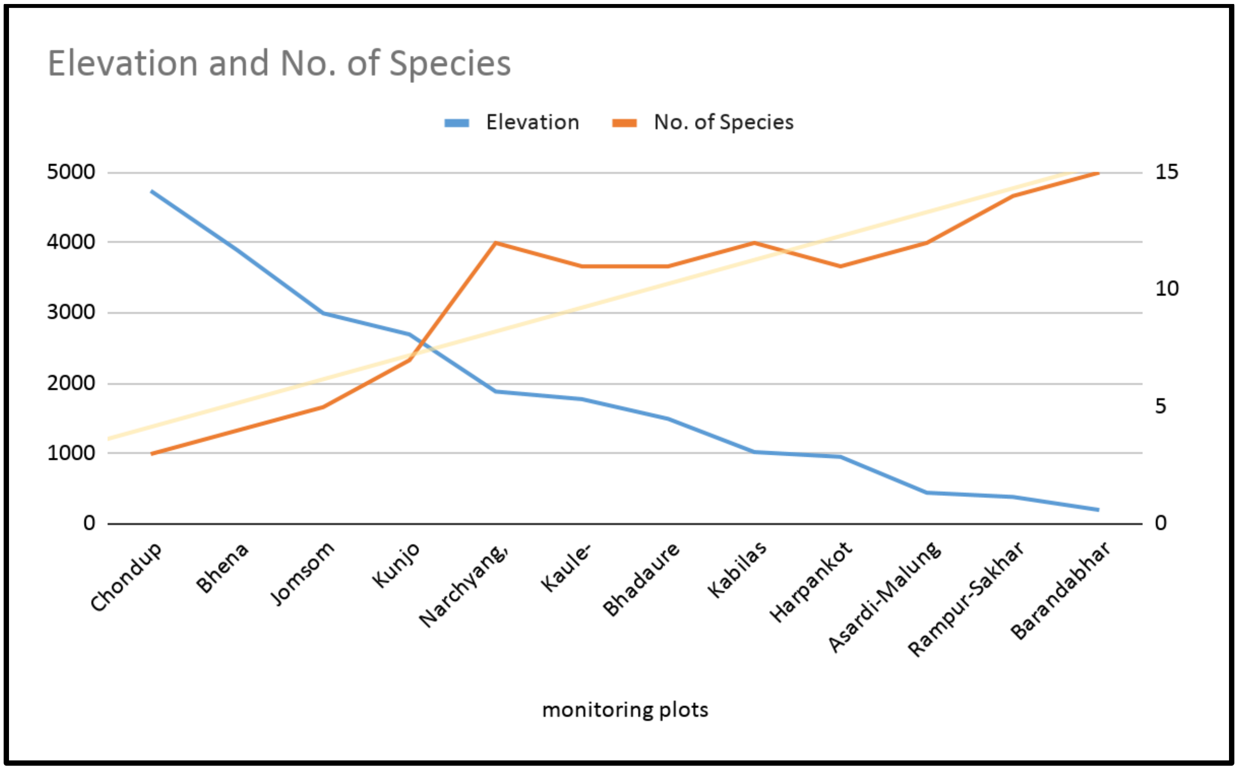


Figure 28: Diversity of mammals along the elevation gradient of CHAL

Similarly, diversity of birds along the elevational gradient pattern shows that bird diversity tends to increase with decrease in elevation. Fewer species were recorded (14-17 species) in the high mountain (above 3000m asl) with lower in the Jomsom area, but species diversity sharply increased in the Kunjo plot which further increases till the Shaktikhor kaule plot at the elevation more than 1700m. However, small drops in bird diversity were seen in the Bhaduare, and Kabilas area. In the end species diversity gradually increased and recorded most in Barandabhar area. (Figure 29, Figure 31). The probability of occupancy multi species of bird found during the survey in climate change plots showed decreasing trend with the increase in elevation (Figure 30a). The community occupancy of bird species showed an increasing trend till 1000m elevation and decreased as the altitude increased as shown in (Figure 30b).

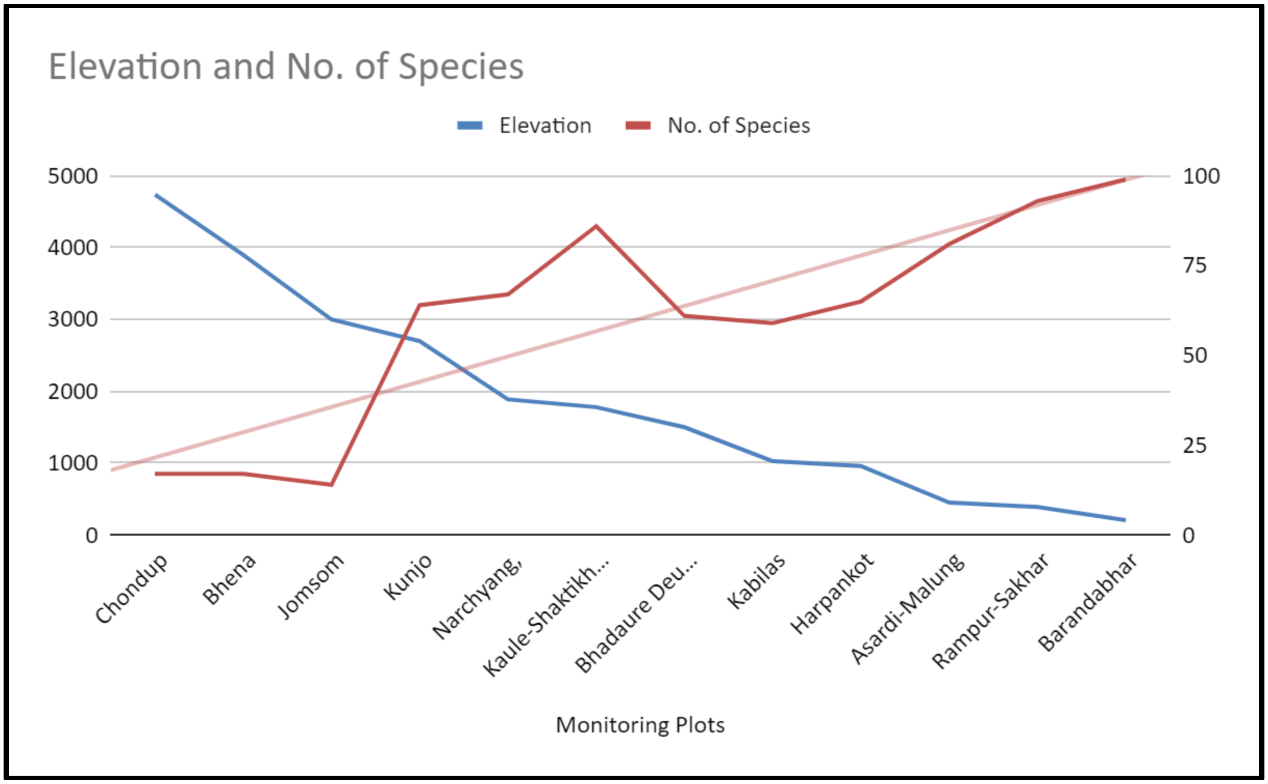
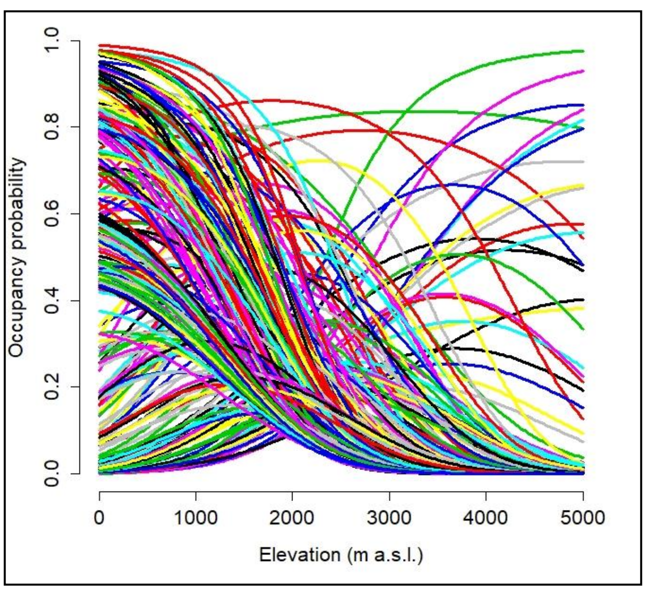


Figure 29: Diversity of birds along the elevation gradient of CHAL



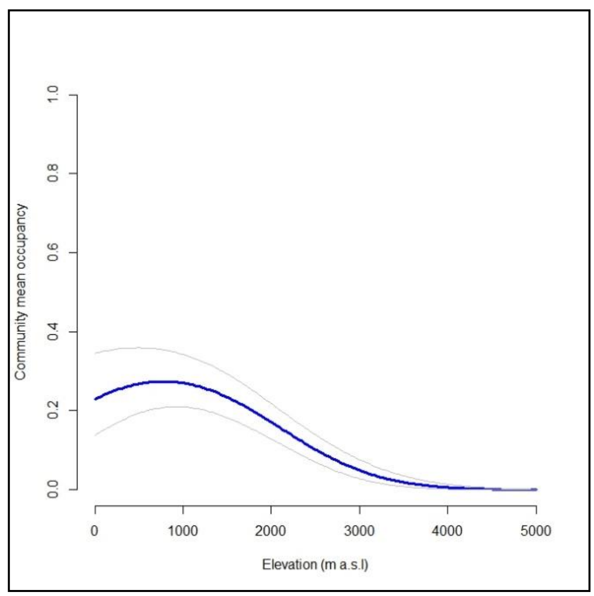


Figure 30 Occupancy of bird species in the elevational gradient of Climate Change Plots in Chitwan Annapurna Landscape (a) Community mean occupancy of birds along the altitudinal gradient (b)

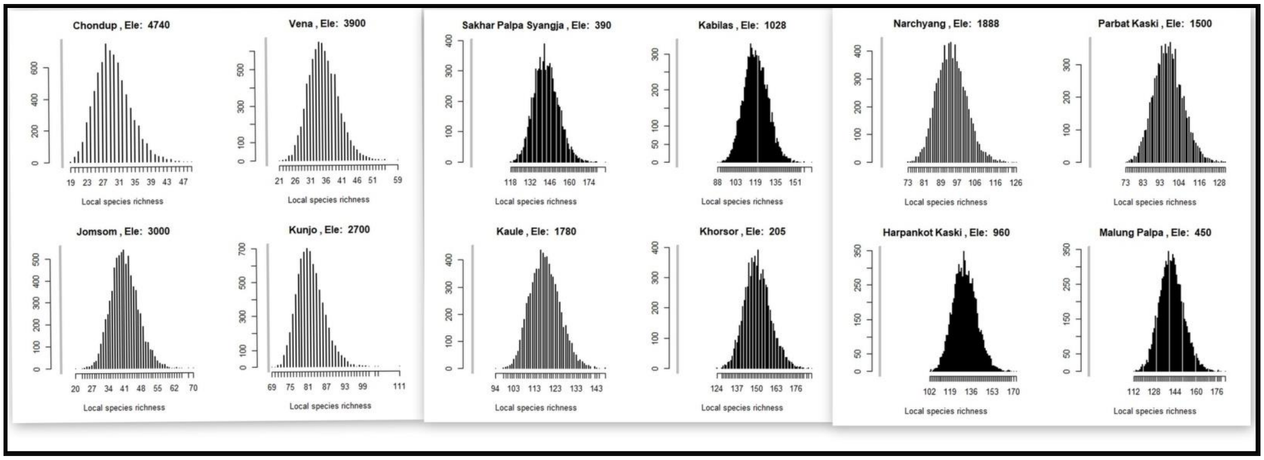


Figure 31 Occupancy of bird species in each site

Diversity of butterflies along the elevational gradient pattern shows that with decrease in temperature, diversity of butterfly's increases. None of the species were recorded in the Jomsom area and very less in the subsequent plot (Chhondup and Bhena). But species diversity gradually increases in Kunjo, Narchayang to reach the peak at Kaule Shaktikhor. However, species diversity decreases in Bhaduare deurali, Kabilas and further decline to Aserdi-malung. Moreover, at the end diversity slightly increases in Rampur and Barandabhar area (Figure 30).

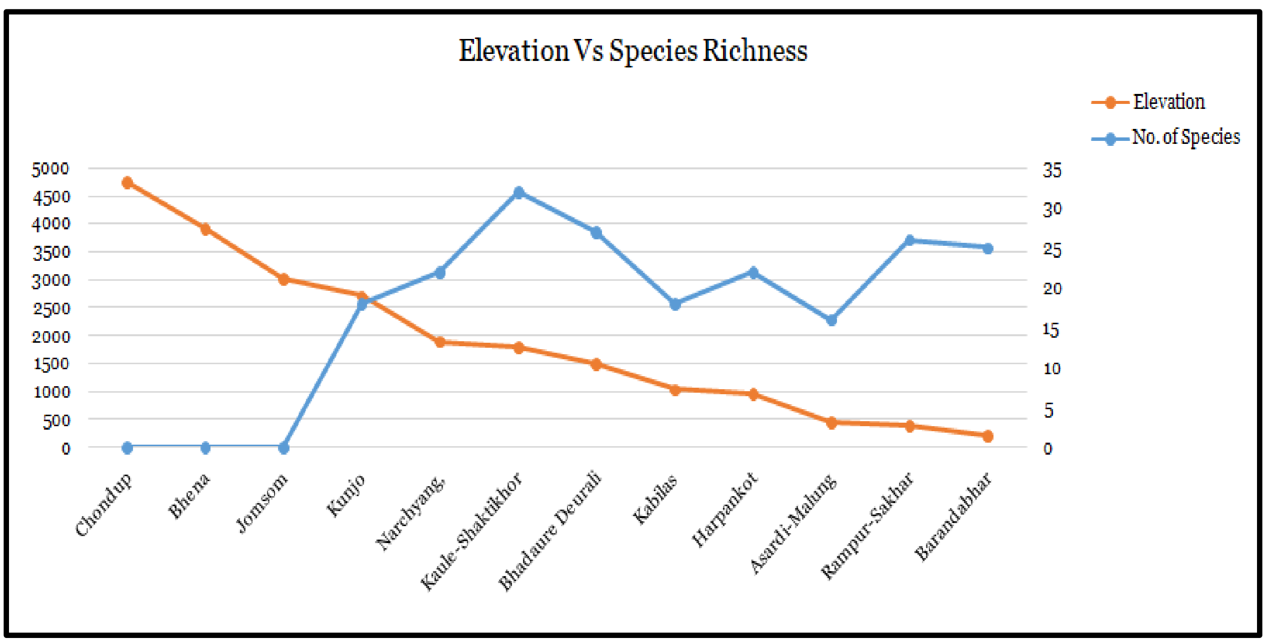


Figure 32: Diversity of Butterflies along the elevation gradient of CHAL

Our elevation vs diversity pattern shows the general pattern of species i.e. the decline of species richness with increasing elevation unlike the humped-shaped curve, a monotonic decrease, or an almost horizontal species richness curve that declines at a certain elevation (Rahbek 1995). The majority of studies about diversity and species richness revealed the predominance of a humped shaped curve of species richness with a mid-elevational peak (Rahbek 2005), although different taxonomic groups could show contrasting patterns (Hofer et al. 2000). This general pattern may be connected with great variation in altitude within a short period of distance unlike the other studies. Moreover as the elevation increases temperature will decrease and with decrease in temperature it is assumed that reduction in the productivity.

2.4. Conclusion

Altogether 54 mammal species, 284 bird species, 107 butterfly's species and 13 species of herpetofauna were identified along the 12 permanent plots. Compiling the data of the previous survey, altogether 77 species of mammals, 337 species of birds and 232 species butterflies has been recorded from the 12 monitoring plots. The survey records eight species of mammal listed as globally threatened while 12 species listed in the national threatened category. Similarly eight species of bird listed in the IUCN threatened species while 16 species listed in the national threatened category. Diversity of mammals and Birds were higher in the lower elevation plots (Barandabhar and Rampur) while fewer species were recorded from the higher altitude. Our mammals and bird diversity along the elevation gradient shows the general pattern of species i.e. the decline of species richness with increasing elevation.

3. CLIMATE CHANGE INDICATOR SPECIES ASSESSMENT

3.1 Introduction

The earth's climate is changing, with global warming becoming indisputable over the last century, the atmosphere and ocean have warmed (IPCC, 2014), already influencing natural systems (Parmesan and Yohe, 2003), with evidences of it threatening the biodiversity (Sinervo et al., 2010) and increasing extinction rates (Foden et al., 2013). The 2014 Intergovernmental Panel on Climate Change (IPCC) estimated that 20-30% of species globally were at increased risk of extinction from climate change impacts if the global mean temperatures were to exceed 2-3C. This has stimulated various conservation programs to mitigate the negative impacts of climate change on different species (Arribas et al., 2012; Shen et al., 2015). Urgent need to identify the most climate change vulnerable species, habitats and regions have been highlighted in study (Balzotti et al., 2016), with some predicting species responses to projected changes to climate potentially enhancing the effectiveness of conservation actions (Guisan et al., 2013).

Climate change will be highly dynamic, with fluctuations above and below the dominant directional change that unfolds over long periods (Easterling and Meehl, 2000; Early and Sax, 2011). The ability of a species to track suitable climatic conditions in the future will also strongly rely on population dynamics and dispersal processes that develop over time (Keith et al., 2008; Early and Sax, 2011). Climate change adaptation strategies for wildlife species require creating a link between an explicitly stated expectation from the changing global climate that could affect the species, their habitats and appropriate actions to address those impacts (Poiani et al., 2011). And in order to conserve the threatened species, it is extremely important to determine the actions to focus on the specific species concerned. To understand what species are in threat and for prompt conservation actions against their extinction, it is hence necessary to assess vulnerability of species in the changing climate. Although there is currently no broad consensus in the scientific literature regarding species vulnerability, the general concept is accepted as an assessment of a species' exposure, sensitivity and adaptability in combination (Foden et al., 2013). Exposure is the extent of climate change and variation that the species encounters and is projected to encounter, sensitivity is the inability of the species to persist, as is, under changing climatic conditions and adaptability is the ability of the species to respond to changes in climate (Advani, 2014).

South and Southeast Asia are projected to get warmer and extreme heat events are projected to increase in magnitude and frequency. Annual precipitation is projected to increase during the wet season and decrease during the dry season in South Asia. Heavy rainfall projections of Southeast Asia that are to increase in magnitude and frequency along with the frequency of droughts are also projected to increase. Temperature is predicted to be warmer at night in comparison to daytime in all seasons, accompanied with higher rainfall and lower dry-season precipitation (Chotamonsak et al., 2011). Studies conducted so far indicate that the mountainous Hind Kush Himalayas (HKH) are warming significantly faster than the global average. By 2050, temperature is projected to increase by about 1-2C or 4-5C on average, depending on the place and region. Although uncertain, precipitation in the higher altitude of the Himalayan region is expected to increase by 5% on average and up to 25% depending on the place and region (Shrestha et al., 2015). Future climate change may have large efforts on species niches, some species even predicted to adapt their bioclimatic niche, migrate to maintain their current niche or become range restricted and undergo population decline, nationally or globally (Holt, 1990).

3.2. Methodology

3.2.1 Selection of species

From the data collected through field work of the project, 54 species were found, out of which 13 species were selected mainly based on their global and national IUCN status considering these species to have low population, limited geographic range, declining population trend and higher vulnerability prospect against climate change (Table 18).

Table 18: Conservation status of recorded mammals

S.N.	Species	Scientific Name	IUCN Status	
			Global	National
1.	Woolly Hare	*Lepus oiostolus*	LC	LC
2.	Royle's Pika	*Ochotona roylei*	LC	LC
3.	Snow Leopard	*Panthera uncia*	EN	EN
4.	Common Leopard	*Panthera pardus*	VU	VU
5.	Himalayan Goral	*Naemorhedus goral*	NT	NT
6.	Himalayan Black Bear	*Ursus thibetanus*	VU	EN
7.	Assam Macaque	*Macaca assamensis*	NT	VU
8.	Crab eating Mongoose	*Herpestes urva*	LC	VU
9.	Common Bentwing bat	*Miniopterus schreibersii*	NT	LC
10.	One Horned Rhinoceros	*Rhinoceros unicornis*	VU	EN
11.	Bengal Tiger	*Panthera tigris tigris*	EN	EN
12.	Asian Elephant	*Elephas maximus*	EN	EN
13.	Sloth Bear	*Melursus ursinus*	VU	EN

Some species like Royle's Pika and Woolly Hare were selected despite their IUCN status as Least Concern in both global and national context. This was done considering the geographical range and temperature tolerance they naturally have and by examining various literature on past research conducted for these species. All of the species were selected after extensive consultation with experts from SMCRF, screened from all 54 species accumulated from the field survey.

3.2.2. Climate Change Vulnerability Assessment for Species

For the assessment part, we referred to WWF Species Assessment Tool that assesses the vulnerability or resilience of species to climate change and is based on four factors:

- Sensitivity
- Adaptive Capacity
- Exposure
- Other Threats

Considering the objectives of the project, we modified the assessment tool to align with the project goal and focused on the first three factors:

3.2.2.a Sensitivity:

This factor describes the intrinsic attributes that are recognized to moderate and/or exacerbate the impact of those pressures on a species response. Categories that fall under evaluating sensitivity are proposed to aid understanding and assessment of how species are sensitive to climate change and require detailed knowledge of focal species and the systems with which they interact (Foden et al., 2019). In terms of lack of such knowledge, sensitivity assessments may have a high degree of uncertainty, often pointing that the species might be vulnerable to extinction.

3.2.2.b Adaptive Capacity:

This factor includes both intrinsic and extrinsic elements and is context-specific (Foden et al., 2019). While the former includes dispersal, phenotypic and genetic attributes, extrinsic factors might constrain or promote the expression of those adaptive capabilities (Foden et al., 2019). So even if a species has high dispersal capacity, its genetic diversity capacity will be low if its surrounding landscape conditions don't give the species enough opportunities to explore. Hence, the fundamental adaptive capacity reflects a species' intrinsic ability to accommodate climate change without significant genetic losses while the realized adaptive capacity reflects how the extrinsic factors might limit expression of those intrinsic adaptive capacity factors (Foden et al., 2019).

3.2.2.c Exposure:

It becomes important to describe and quantify the exposure to climate change of a species, especially since it is not a natural prospect for species to naturally expose themselves towards climate change impacts. Rather, the climate change drivers that result from pressures in the species and their habitat is more important to be understood. In the context of climate change and species, studies have proposed a pressure classification that includes three broad categories: Abiotic pressures, biotic pressures and human response pressures. Abiotic pressures include climate changes driven by changes in atmospheric concentrations of greenhouse gases, resulting effects on the physical environment and direct effects of the changes in greenhouse gas concentrations. Biotic pressures result from changes in ecological processes (Ockendon et al., 2014), along with those mediated through changes in habitat availability or community composition as well as direct effects of the changes in greenhouse gas concentrations. Human response pressures could be exerted from societal actions resulting from climate change, including actions used to mitigate and adapt the changing climate, although they are poorly recognized in vulnerability assessments (Maxwell et al., 2015; Turner et al., 2010, Watson & Segan, 2013).

3.2.3. Literature review, expert consultation and online survey

Once the assessment toolkit was ready, extensive literature review was conducted in order to find the right information required in the toolkit. Experts of specific species were contacted to review the collected information and correct any misinformed data. Due to Covid-19's national lockdown, consultation with experts got shrinked into digital communication and online surveys. Hence, Monkey Survey website was used to create a quick online survey for the experts that enlisted questions from the assessment toolkit. Answers provided were then compared with the information available and with further consultation, ratings for each species in each category was given.

3.2.4. Vulnerability Rating

Unlike other studies where categories are listed from High-Low, in case of our project, points (1-4) were given to different categories depending on the different options in the assessment tool, so, lower the vulnerability factors, lesser the points and higher the vulnerability factors, higher the point. This was done in order to find the most vulnerable species through numerical data. Species were compared with each other in order to give the points. For example, for reproductive rate Asian Elephant has been rated Low (3) in comparison to Snow Leopard that is rated Medium (2). This is directly related to Asian elephants breeding every 4-5 years with a single offspring after a gestation period of 18-23 months, whilst Snow Leopards have 1-5 offspring after a gestation period of 90-105 days. Comparative rating was done similarly to all the factors in the index.

3.3. Results and Discussions

All the 13 species were credited with points based on the different features and factors in the assessment index. Overall score of the index was 68, making 34 the average point of the total. The Assam Macaque *(M.assamensis)* scored the lowest (27) and the

Greater one-horned Rhino *(R.unicornis)* scored the highest (40) out of the 13 species (Table 31).

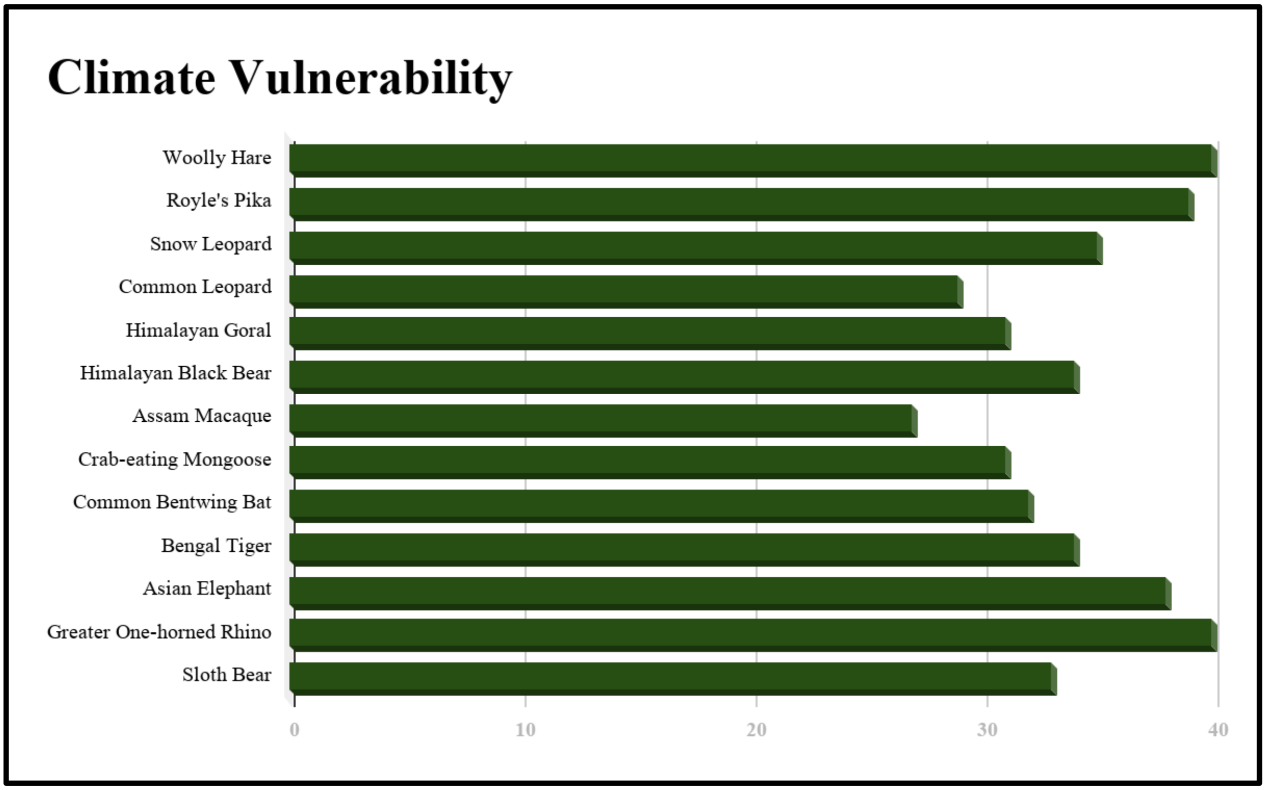


Figure 33: Climate vulnerability of recorded mammals

7 species that scored the average and above were denoted to be climate vulnerable species. The species were namely: Himalayan Black Bear *(U.thibetanus)*, Bengal Tiger *(P.tigris tigris)*, Snow Leopard *(P. uncia)*, Asian Elephant *(E.maximus)*, Royle's Pika *(O.roylei)*, Woolly Hare *(L.oiostolus)*, Greater One-horned Rhino *(R.unicornis)*. Out of these seven species, according to the IUCN Red List Data book, two species are listed Least Concern (Royle's Pika and Woolly Hare), three species are Endangered (Snow Leopard, Bengal Tiger and Asian Elephant) and two species are globally Vulnerable and nationally Endangered (Himalayan Black Bear and Greater one-horned rhinoceros).

Each of these species scored more in the sensitivity, adaptive capacity and exposure factors in comparison to the rest of the species. The vulnerability was hence indicated to be higher, with the highest being that of the Greater One-horned Rhino of the selected 7 (Figure 32).

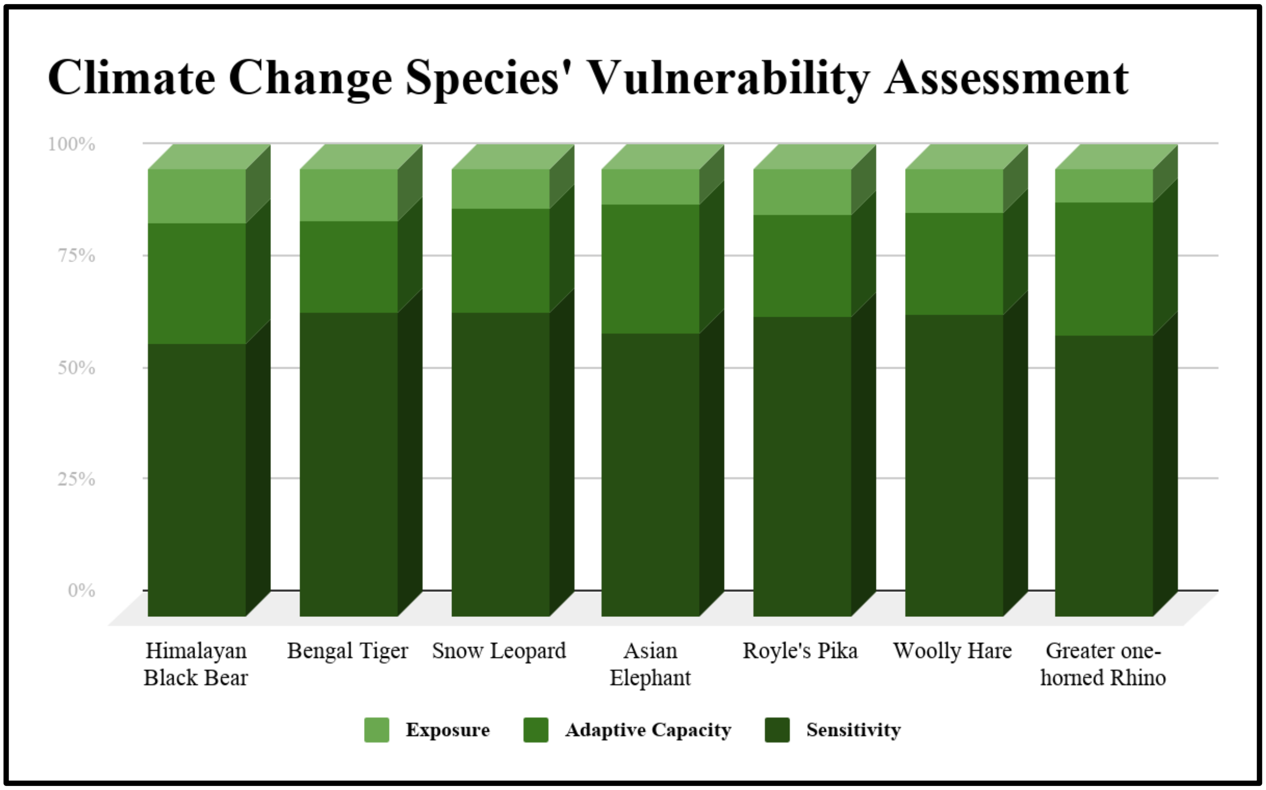
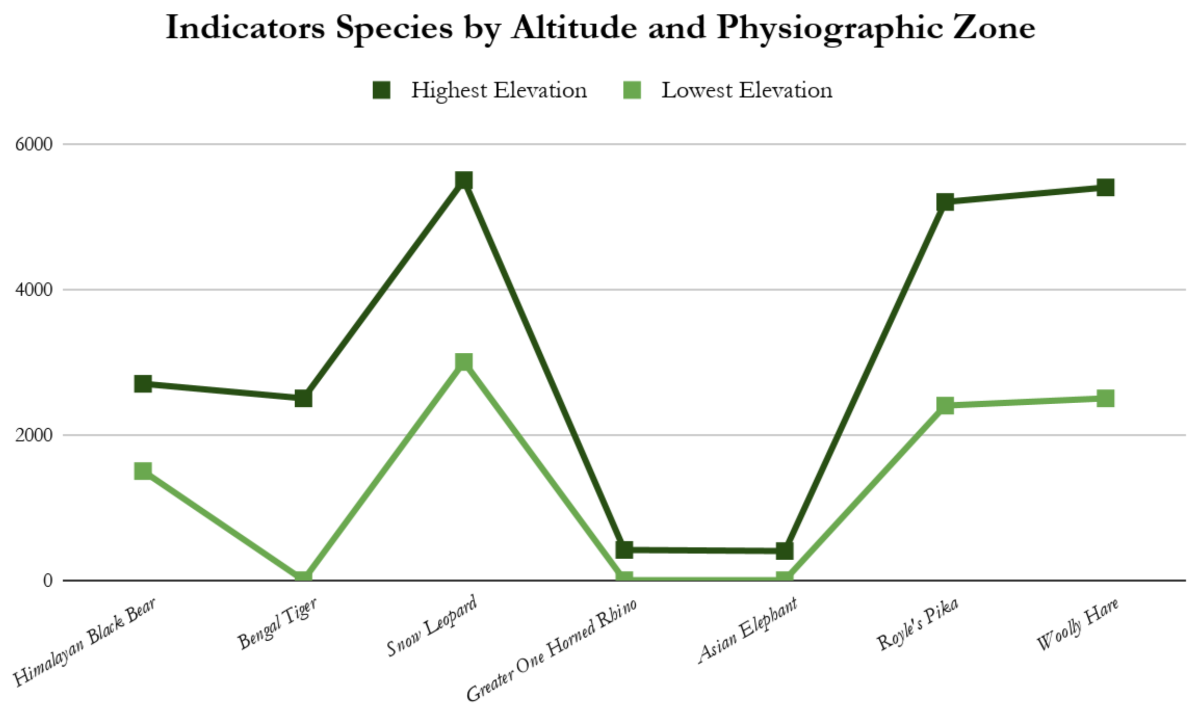


Figure 34: Assessment of climate change vulnerability of recorded species

3.3.1 Climate Indicator species by altitude and physiographic zone

Based on our vulnerable assessment study, the seven species depicted as climate indicators can be divided according to their elevation. The following graph shows the elevation of each species from its highest to its lowest elevation. This is essential information as it can help the monitoring mechanism for local level monitoring in the study plots. The seven climate indicator species are found in different physiographic zones, and can be divided accordingly.



3.3.1 High Mountain (3000m+)

The higher altitude regions that fall above 3000m sea level have been categorized as high mountain regions for the project. Under this area, the following species have been identified as climate indicator species for specific reasons:

a) Royle's Pika (*Ochotona roylei*)

It feeds on a variety of grasses, sedges, weeds and woody plants fresh and sometimes in the form of hay which they make themselves. They also eat lichens and mosses, utilizing whatever plants they can find near their burrows. The litter size of Royle's Pika ranges from 1-5 and the average gestation period is 30 days. Its generation time is very short, which is just 8 months. However, despite their short generation time, increasing temperature could lead to decrease in their food abundance, causing loss of life.

Royle's Pika avoids heat stress by reducing activity during warm midday hours and taking shelter in micro climatically favourable cooler talus habitat. Study shows that changes in habitat microclimatic conditions (specifically, increases in temperature) might significantly restrict Royle's Pika daytime activity (Bhattacharya et al., 2014). Thick snow cover acts as a protective insulation layer for pikas during winter, allowing them to survive large diel temperature fluctuations during winter and early spring (Morrison and Hik, 2007). As the species does not hibernate in winter and does not construct hay-piles for winter food (Kawamichi, 1968), snow thickness plays an essential factor for the pikas to live through harsh winters. However, this could be affected by rise in temperature in the higher altitude.

Climate change may have a severe impact on their habitat and vegetation as well. Winter snow covers are known to protect alpine plants from extreme cold and fluctuating temperatures (Marchand, 1996). But, the change in climate is already affecting ecosystem services by affecting forest type and area, primary productivity of the vegetation which ultimately affects the species' populations and migration, the occurrence of pests and disease, and forest regeneration (Karki et al., 2014).

b. Woolly Hare (*Lepus oiostolus*)

The Woolly Hare are primarily nocturnal, although they can be seen active during the day. They are known to rest in quiet, low areas exposed to the sun, but sheltered from the wind during the day. They primarily feed in grasses and herbaceous although their food abundance is known to be high in spring but medium in winter. Climatic changes however might affect this eating and food abundance pattern, causing population decline in the species.

The mammal has shown symptoms of dyspnea (Lu, 2011) although a lot of information is still lacking about this species. This gap in information could be extremely risky, especially since limited research in the species would restrict applicable methods to conserve the species. Although they have a short generation period of 8 months and the annual litter has 4 to 6 young ones, lack of genetic information and their dispersal ability is another setback in the species. With such less information and their climatic habitat changing rapidly, the species are vulnerable to climate change.

c. Snow Leopard *(Panthera uncia)*

However, despite the species' temperature tolerance, snow leopards are indirectly affected by the changing climate. As the climate changes, the treeline shift experienced in the higher altitudes affects the grazing area of the snow leopard's prey species like Ibex, Blue Seep and Himalayan Tahr. This is why they end up in contact with humans and livestocks. Loss in their prey species like Marmot, Pika, Hares, small rodents and game birds such as the Snowcock and Chukar Partridge that also supplements the snow leopard's diet, the concerned species faces conflict with human communities. Although the species is known to prey in smaller species like

The habitat of snow leopard, mountain ranges are likely to be some of the most severely impacted ecosystems in the world from future climate change. The tree line shift due to the rise in temperature have created competition with other carnivores. Snow leopards face the conservation challenges like naturally occurring in low densities, extensive home ranges, dependence on vulnerable prey populations and high susceptibility to poaching and other anthropogenic threats. Enhancing the existing threats climate change has accelerated population reduction and eventually local extinction (Sathyakumar and Mathur, 2015).

3.3.2 Middle Hills/Mountain (500 - 2800m)

The mid hills altitude regions that fall between 500-2800m above sea level have been categorized as middle hills and mountain regions for the project. Under this area, the following species have been identified as climate indicator species for specific reasons:

a. Himalayan Black Bear (Ursus thibetanus)

The movement and ranging of the black bear is largely dependent on the quality, quantity and distribution of food which in turn is influenced by topography and climate. Climatic variation and warmer winters have changed the habits of these species, affecting their hibernation period due to less winter and temperature rise earlier than expected over the past few years.

Himalayan black bears have been known to strip the bark off of trees in order to supplement their deficient diet with nutrients. Their normal diet consists of fruits, roots and tubers, as well as small invertebrates and vertebrates, and carrion. The species are omnivores in their food habits, foraging largely on fruits and to some extent on leaf material, 6 Technical Report grasses, insects and other animal matter (Charoo et al., 2009). However, change in the climate could also mean change in the food abundance, causing the species to come closer to human communities and ultimately causing conflict between them.

Climate change will have a profound effect on the future distribution, productivity, and ecological health of forests. There could be a significant reduction in alpine and cryospheric ecosystems and their services (Karki et al., 2014). With that the estimated available area of suitable habitat for this species has declined by approximately 30% over the past 10 years (Jnawali et al., 2011).

b. **Bengal Tiger (*Panthera tigris tigris*)**

The majority of the tiger's diet consists of various large ungulate species that depend on grasslands and shrublands for their food. However, climate change has already been affecting these habitats and limited food sources for the prey species would mean limited prey species for the tiger as well. This effect in the food chain would increase the species' competition and an increased competition for food in a limited food resource area can further bring conflict, often leading to human-wildlife conflict.

Increase in climatic variability like flood and landslide also affects the habitat of the tigers, displacing them from their usual vegetation and often leading to death. This pattern could further risk the species since their longer generation period and low number of cubs annually will affect the overall population of the species.

3.3.3 Siwalik (below 500m)

The mid hills altitude regions that fall below 500m sea level have been categorized as Siwalik regions for the project. Under this area, the following species have been identified as climate indicator species for specific reasons:

a. **Asian Elephant (*Elephas maximus*)**

The mammal feeds on a wide variety of plant species, including grasses, woody plants and some cultivated crops. Adults can eat approximately 150kg daily. However, invasive plants have a negative impact on elephants, primarily through a reduction in grass cover and other preferred plants. Though their diverse diets add to their ability to adapt to climate change, a number of other traits make them vulnerable, including sensitivity to high temperatures and reliance on large amounts of water. Asian elephants need a lot of water - up to 225 liters per day - so, the herds stick close to a fresh source. Thermoregulation becomes an issue for elephants in extreme weather conditions due to their extremely small surface-to-volume ratio, high energetic costs of body cooling (Weissenbock et al., 2011) and lack of sweat glands to dissipate heat.

b. **Greater One-Horned Rhino (*Rhinoceros unicornis*)**

The mammal reproduces a single calf after a gestation period of 16 months. This long generation time causes slow reproduction in the species and with recent identification of disease in the species, rhinos are highly at risk due to change in climate. The rhinoceros conservation action plan for Nepal (2017-2021) has acknowledged that climate change is emerging as a serious threat to the species and there is a knowledge gap concerning the impact of climate change (DNPWC, 2017). Recent climate-induced phenomena such as flash-floods, prolonged droughts and frequent forest fires could have an effect on rhinoceros and its habitat.

Though a generalist in diet that depends on floodplains and riverine grasslands for food, reduction of rhinos in the past was mainly caused by the disappearance of alluvial plain grasslands that are used by the growing human population for settlement. This has caused human-rhino conflicts as the animals more frequently visit villages to forage.

Along with direct impacts, rhinos are vulnerable to secondary impacts of the climate crisis. The most important plant species in their diet are likely to shift their ranges as climate conditions change, or they be forced out as invasive species start colonizing new areas. With less food and more competition for what's left, the rhinos are less likely to breed and prosper successfully.

3.2.5. Climate Change Bird Species

Birds have been subjected to changes due to habitat degradation along with these indirect effects from humans such as climate change and other disturbances. When these factors are coupled with limitations based on specialization, certain species are more influenced than others (Julliard et al 2003). It is suggested that climate change will adverse effect on island or mountaintop species (Newton, 1998). As a general rule, if a habitat is reduced in area by 50%, about 10% of the species will be lost, and if the habitat area is reduced by 90%, about 50% of the species will be lost (Newton, 1998). Organisms in tropical forests are in particular danger due to their high rates of habitat destruction (Newton, 1998). Phenology is a critical part in the annual cycle of migratory birds: bird migration, breeding, and nesting are timed every spring to coincide with the peak availability of critical food sources in a delicate synchronization that occurs across large latitudinal gradients and diverse habitats. This synchrony between birds and key resources helps to ensure that birds survive migration and successfully reproduce. When temperatures and precipitation patterns change, many species of plants, insects, and birds have advanced important phenological events. Plants are putting out leaves earlier, insects are emerging sooner, and many birds have advanced the timing of their migration. These changes have been observed for many decades and across different habitat types, although impacts vary between species. The study on Great tit, is a European songbird that relies on a short burst of caterpillar availability each spring to feed its young. Over the past decades, temperatures have warmed and caterpillars are consistently emerging earlier. The great tit, however, has not advanced its egg-laying date as fast as the caterpillar has advanced its peak biomass date, and so many young nestlings are born too late to benefit from the short caterpillar supply. This type of phenological mismatch could have serious demographic consequences for migratory birds, and could ultimately cause a decline in population levels. From our survey and based on the vulnerability assessment on mammals species, these bird species could be indicator species of climate change though further detailed assessment is needed.

Cotton Pygmy Goose

Location: Barandabhar (Plot 1)

The species is nationally Vulnerable, local resident and summer visitor in the lowlands. The species is moved in response to rain and water availability. The species is restricted below 900m mostly concentrated in the lowland having estimated population less than 1000 in Nepal. It has declined at a few sites including the three most important known localities for the species: Koshi Barrage/Koshi Tappu Wildlife Reserve, Ghodaghodi Tal and Shukla Phanta National Park (Inskipp et al. 2011). They are wetland-dependent as they inhabit reed edged pools partly covered with vegetation. Moreover, it is a cavity nester that uses hollows of mature trees at close proximity to the wetland (Upadhyaya and Saikia, 2010). Since wetland systems are vulnerable to climate changes and it is expected that climate change will have a pronounced effect on wetlands through alterations in hydrological regimes with great global variability (Erwin, 2008). This will impact the population of the species along with human anthropogenic threats like hunting and disturbance, and the loss and degradation of wetlands (Inskipp et al. 2011).

Brown Dipper

Location: Kunjo and Harpankot

Brown Dipper is a specialist of fast-flowing streams, feeding mainly on aquatic macroinvertebrates (Chiu et al. 2009). The species is indicator of freshwater ecosystem. The habitat of the species are rapid mountain rivers with rocky shores, and mainly larger rivers in the forest belt. The elevation range of the species is 4960 m- 1525 m during summer and 3100 m – 455 m during winter. The species is highly threatened by water pollution caused by a high input of sewage, as well as other domestic and industrial pollutants. Likewise, the removal of bankside and hillside cover, cultivation of hillsides and diversion of the water from streams for irrigation also makes unsuitability for the species which depends on large aquatic benthic invertebrate (Tyler and Ormerod, 1991). Changing temperature and precipitation will fluctuates the reproduction of macroinvertebrates which will directly impact the Brown Dipper diet. If the reproduction of macroinvertebrates occurs slightly earlier than breeding of Brown Dipper, it will impact the breeding success of the Brown Dipper. On addition to that the higher mountain is facing multiple anthropogenic threats, and climate change is further taking a toll on this biodiversity rich region (Gupta et al., 2015). The altitudinal distribution of species are highly affected by climate change. Therefore, considering all the threats faced by Brown Dipper, the species could be climatically vulnerable species.

Greater Hornbill

(Location: Barandabhar)

The rare species is listed as Endangered nationally and Vulnerable globally.

Greater hornbill is a rare and local resident, habitant of elevation below 100m. In Nepal, it has been recorded from few location with estimated population below 150 individuals (Inskippe et al. 2016) which is decreasing. Greater Hornbill require extensive spatial areas to support their ecological and behavioral requirements (Thapa et al., 2015). Being large and slow-breeding bird species it typically rely on large tracts of forest and reliable access to fruits and cavities in trees. Moreover, the species need specialized niche for breeding purposes. The major threat faced by the species are deforestation, especially loss of mature fruiting trees as food sources and nest sites for hornbills; it is also at risk from hunting (illegal in protected areas) for its casque and oil and as food (Inskipp et al., 2016). However, the population trend of the bird species is decreasing and equally threatened by climate change because of its specialized need of niche.

Cheer Pheasant

Location: Kunjo
The Cheer Pheasant is listed Endangered nationally and Vulnerable globally. In Nepal, It is a local resident, endemic species to the Indian subcontinent and where it is restricted to a narrow belt of the Himalayas. The habitat elevation of the species ranges from 3050 m to 1445 m. The species moves to lower elevation in the peak winter season avoiding heavy snowfall. The species is found in pine dominated forest which is threatened habitat for wildfire. As the temperature raises more frequent wildfire will occurs in the forest which will threatened the ground dwelling, non-migratory and restricted range species like Cheer Pheasant. Moreover anthropogenic stresses like snaring, hunting, overgrazing, deforestation will also impact the species. Moreover based on climate impact projections, alpine grassland (habitat of Cheer Pheasant) could become encroached by upslope forest migrations (Forrest et al. 2011).

Lesser adjutant (Location: Barandabhar)

The species is vulnerable both globally and nationally. In Nepal, the species is the main resident of Eastern region while it is also now recorded in more localities in the West of Nepal. Its population is recorded below 1000 in Nepal and habitat elevation lies - between 75-250m. The species natural distribution of the species is mainly controlled by climate (Rosenzweig, et al., 2008). The species distribution and the physical environment show a consistence association (Elith and Leathwick, 2009). Likewise, the fossils evidence shows profound effect of climate change to the species (Walther et al., 2002).The species is resident subject to seasonal movements (Ali and Ripley 1987). The lesser adjutant stalks around wetlands feeding mainly on fish, frogs, reptiles, large invertebrates, rodents, small mammals and rarely carrion. The prey species of Lesser Adjutant would be impacted by the climate change as well human induced intervention like uses of pesticides on the agricultural land will impact the population of the species. Moreover due to climate changes small ponds and wetlands will be lost and anthropogenic stresses like habitat loss and alteration, disturbance, hunting for food and medicinal purposes, changes in agricultural practices from paddy fields to cash crops, and pesticide use in agricultural lands, and development will impact the species. The species will be threatened by poisoning of wetlands to capture fish, water pollution by factory effluents and the invasive spread of Water Hyacinth. Likewise, the distribution of the species has been impacted due many threats out of which climate change is a chief threat consequently the change in climate has introduced new pathogens and exotic species enhancing the threats to the species.

River Lapwing

(Aserdi-Malung, Rampur and Khorsor)

River Lapwing is near threatened nationally and both globally. It is a common resident and widespread resident of low land and inner Himalaya foothills of Nepal (Inskipp et al., 2016). It resides between the altitude of 915 m to 73 m. River lapwings are an example of waders, which predominantly prefer open habitat that contains plenty of water. The species share a range of habitats such as low wet grasslands, edges of lakes, sandy inland, river banks, steppes, arable, and dry grasslands (Ali and Ripley 1980; Duckworth et al 1998; MacDonald and Bolton 2008; Maruyama et al 2010). In Nepal, it has been recorded from far-west to far-east along with several protected areas and outside protected areas. It highly depends on freshwater and many global factors have imperiled freshwater biodiversity. The human-induced global climate change has caused higher temperature and shifts in precipitation and river run-off (IPCC, 2007). Due to climate change, freshwaters are experiencing declines in biodiversity far greater than those in the most affected terrestrial ecosystem (Saikia, 2013). The population trend of the species shows declination on the Narayani and Rapti Rivers in Chitwan National Park while the population is uncertain in other regions (Inskipp et al., 2016). Hence, River lapwing could be considered as climatically vulnerable species observing the consistent threats it seems to face.

Asian Woollyneck (Rampur)

Asian Woollyneck is Near threatened nationally and Vulnerable globally. It is a common resident which lie at an altitude between 915 m and 75 m in Nepal (Inskipp et al., 2016). It has been recorded from most of the protected areas of Nepal. It inhabits flooded fields, marshes and lakes (Inskipp and Inskipp 1991). It is a solitary bird and is usually observed alone, walking slowly on the ground or along water, occasionally in small group. The species hunts on dry or marshy ground and wet grasslands; rarely wades (Grimmett et al., 1998). The major threat to the species is habitat loss and habitat degradation. Likewise, hunting, disturbances in the nesting sites, decrease in number of prey species due to the use of agro-chemical are the other threats to the species (Inskipp et al., 2016). Although, the exact population status of the species is not known, there is an indication that number of the species is decreasing due to the threats faced by the species. Observing the existing threats and its niche, the threatened species could also be vulnerable even due to a small fluctuation in climatic factor.

Bearded Vulture (Chhondup, Jomsom)

Bearded Vulture is vulnerable in the national status and Near Threatened in the global status. Bearded vulture is a common and widespread resident in the Himalayas often above the treeline. It is the habitant of the elevation between 1200m-4100 m although occasionally it is seen much higher. It is mainly a bone scavenger but also feeds fresh and old carrion, and often scavenges on refuse and offal near human settlements (Naoroji 2006). The main threat to the species is toxic substance, diclofenac and some other NSAIDs, fungicides, herbicides and pesticides are also harmful. Regarding the population trend, a more recent study confirmed a substantial decline between 2002 and 2008 but showed a stabilized population trend between 2008 and 2014 (Inskipp et al., 2016). The biodiversity of higher mountain region are having an adverse effect due to global climate change. The niche requirement for its survival has an impact due to change in climatic condition and may be its unstable population faces serious affect in the near future.

3.4. Conclusion

As it has been frequently highlighted that South and Southeast Asia are projected to get warmer and experience extreme heat events, species in general are already experiencing such phenomena in their habitat. Understanding the impacts of such climatic variability to species and identifying climate vulnerable species can play a vital role in developing effective biodiversity conservation plans. By assessing the species' sensitivity, adaptive capacity and exposure to climatic variability, it becomes more smoother to determine which species in which habitat and regions are most at risk from climate change.

From our study, we identified 7 species that could be climate change indicators in Nepal and proper monitoring of these species in their habitat is essential. Especially for larger mammals like Asian Elephant and Greater One-horned Rhinoceros that are even more vulnerable to climate change due to their longer generation time, large body mass and freshwater requirement to combat heat from their body. That being said, it is unwise to think that some other species as Royle's Pika is less vulnerable in comparison to the larger mammals as the Royle's Pika heavily depends upon winter snow's thickness for thermoregulation. Climate change could bring an even harsher impact to these pika species if proper conservation action isn't conducted timely. Therefore, each species, large or small, must be assessed for climate change vulnerability in order to encompass global conservation of wildlife. Moreover, in general assessment eight species of birds, Cotton Pygmy Goose, Brown Dipper, Great Hornbill, Cheer Pheasant, Lesser Adjutant, River Lapwing, Asian Woollyneck and Bearded Vulture could be indicator species of climate change though further detailed assessment in necessary.

The climate change vulnerability assessment is a unique tool that can help in identifying such species and must be put into further practice. Assessing species vulnerability to climate change is an essential prerequisite for developing effective strategies to conserve them. Conservation can be even more effective if assessment as these can be elevated and more at risk species can be detected prior to things getting worse. If prompt action for conservation and management of wildlife is not done, then just like in 2016, when the biodiversity lost Bramble Cay melomys *(Melomys rubicola)* due to climate change, the world will also be facing numerous other accounts of species extinction in the future.

4. LOCAL MONITORING MECHANISM AND CAPACITY DEVELOPMENT

4.1. Introduction

Global climate change is now recognized as an important driver of ecological change (Parmesan 2005). While the general trajectories and velocities of responses by species and natural communities to these ambient climatic changes can be predicted through analyses of various data sources and climate models (Dawson et al., 2011) the specific impacts on natural ecosystems, including ecosystem processes and service delivery is unclear and uncertain (Parmesan 2005). Recent assessments have predicted that the average annual temperature in the Himalayas will increase faster than the global average and precipitation patterns are also expected to change (Beaumont et al., 2010; IPCC 2007, Li et al. 2013; Shrestha et al., 2012; Xu et al., 2009).

Climate change is expected to cause changes to the distribution and composition of plant species in forest and grassland ecosystems (Kelly and Goulden 2008). Moreover, the impacts differ from region to region, country to country, sector to sector and community to community (Adger et al., 2004; Kasperson and Kasperson 2001). Poor and agrarian communities of the developing countries are affected most by climate change because they have poor adaptive capacity and limited access to alternate means of production (IPCC 2007; Skoufias et al., 2011). Agriculture in particular is one of the most susceptible secors to climate change (Kurukularusiya and Rosenthal 2003) and within the agricultural sector, livestock production is the most climate-sensitive economic area (IPCC 2007). Although numerous local factors affect vulnerability to climate change (Wooda et al., 2014), livestock smallholders in developing countries are highly affected and most vulnerable to such changes (Heltberg et al., 2009). Livestock is an essential part of the farming system in the socio-economical life of Nepal that contributes nearly 26% to the total agricultural gross domestic product (MOAD 2012) in the country. Almost 87% of the households in the country keep some kind of livestock (IRIN 2013). Grain cultivation and livestock production are inseparable livelihood activities in Nepal. These activities complement each other, and the majority of households combine subsistence crop production with small numbers of livestock and thus are referred to as mixed agro-live-stock smallholders. However, there is very little information on how vulnerable mixed agro-livestock smallholders are to climate change and how vulnerability differs across different agro-ecological zones of Nepal.

4.2. Methodology

4.2.1. Local-level monitoring mechanism

Loss and degradation of natural habitats, poaching and the illicit trade of animal parts pose a major threat to wildlife, particularly in least developed countries like Nepal. The Living Planet Report 2014 indicates that poaching threatens all wildlife species, particularly vertebrate species whose population have halved in size within the last four decades (WWF International and ZSL, 2014). Assessing the population status of wildlife species is hence one major reason why monitoring of wildlife is important. Conversely, a rapid population increase of certain wildlife species can pose a threat to human livelihoods (Kaswamila et al., 2007, Acharya et al., 2016). In such circumstances, wildlife monitoring can help to minimize the risk of possible human-wildlife conflict (Latham et al., 2015; Kays et al., 2015). Monitoring wildlife by keeping track of animal movements, studying the population distribution, natural habitat conditions and identification of possible threats to different wildlife species like poaching is essential to understand the status of different wildlife species and contribute to better conservation overall.

The use of new and advanced wildlife monitoring technologies is shifting the paradigm of wildlife conservation and management. These digital technologies are helping wildlife conservationists and researchers around the world to monitor and manage wildlife with more precision and efficiency. Modern monitoring devices such as camera traps, collaring devices and GPS have supported local communities in claiming, defending and monitoring their natural resources (Arts et al., 2015), along with modifying the way nature conservation is perceived by citizens. Modern tools mediate our relation to wildlife and in turn, influence the type of conservation policies chosen and implemented (Buscher, 2016). Camera trap data from the TAL-Nepal region provided valid evidence of genetic flow between tigers of India and Nepal. As a result, trans-boundary resolutions were signed in 2010 by both governments dedicated towards the conservation of Royal Bengal tigers (WWF-Nepal, 2010). Such policy implications of using monitoring technologies for wildlife conservation not only benefit wildlife populations but also have a positive impact on human populations living in the vicinity of PAs and buffer zones (Shrestha and Lapeyre, 2018).

Dependable monitoring programs are required to understand the extent and drivers of these declines, guide management action to slow or stop them, and assess the effectiveness of such conservation interventions (Burton, 2012). Moreover, studies (Moller et al., 2004; Schmidt and Stricker, 2010) have suggested that engaging local people and their local knowledge in wildlife monitoring will not only increase the effectiveness of the wildlife conservation, but will also decrease conflicts, promote healthy dialogue between conservationists and local experts, further our understanding of biodiversity and contribute to long-term sustainability. Aligning to the objective of the project, the project identified areas of support for long-term monitoring and engagement with each local school and key stakeholders to sustain monitoring mechanisms and support relevant areas.

The following steps were taken in order to initiate a local-level monitoring mechanism and conduct capacity development of wildlife monitoring in the communities nearby the plots.

4.2.1.a Development of training module

With previous works conducted by NTNC in the plots, the theme and criteria of the modules were created accordingly. Focusing on the objectives of the projects, the module concerned the following topics:

- Overview on climate change
- Equipments introduction
- Wildlife monitoring protocol
- Practical demonstration

The outcomes focused mainly on awareness of climate change, knowledge enhancement on situational comparison of climate change impacts on biodiversity and local species along with handling technical equipment related to monitoring. Online resources and secondary datas were referred to create the module. Each module was designed to fit the weather condition of each monitoring plot and were shared with experts from SMCRF. Final version of the module was then taken to the field for implementation.

4.2.1.b Selection of participants

From the previously identified 12 schools and communities nearby the permanent plots, 15 participants were selected in the format:

- 2 teachers
- 8 students
- 5 local community representatives

The participants were selected based on their willingness, past social activities and leadership experience. The people were nominated by their respective community groups who were familiar with the local topography, flora/fauna, and literate enough to be capable of completing data sheets and handling equipment for long-term monitoring practices.

4.2.1.c Climate change discussion

As per the module, facilitators first discussed climate change with the participants. The facilitator gave information on what climate change is, the global situations of climate change, direct and indirect impacts of climate change on biodiversity and local species. Then the discussion fixated towards the local people as they shared their personal experiences on climate change. Facilitators used visual display and technical mediums to show the impacts of climate change in different places and more discussions were conducted about climate change. Notes and minutes were taken throughout the session.

4.2.1.d Wildlife monitoring protocol

Given the various advantages of using modern wildlife monitoring technologies in wildlife conservation, the government of Nepal and its local and international conservation partners have also been using and experimenting such technologies in the Terai Arc Landscape (TAL) in Nepal. Monitoring technologies such as radio collars and camera traps have been in use since the late 1990s in protected areas (PAs), satellite collars since early 2000s, as well as conservation drones since 2012, to study and monitor endangered flagship species.

However, an increased digital divide might create a clear segregation between well-endowed conservation organizations and isolated rural communities with lower capabilities (Arts et al., 2015). In general, biodiversity and field monitoring protocols are developed in order to help project proponents, policy makers and other stakeholders to design and implement monitoring of flora and fauna of a concerned area. The monitoring protocols help in achieving targets and standards along with contribute to the avoidance of any negative impacts on biodiversity conservation (NTNC, 2018). The field monitoring protocol created by this project is prepared in the simplest format in order to ensure the community will be able to understand and use it in the future. A general information on survey and monitoring procedure, data recording and reporting was hence included in the protocol so that the local community can use it as reference. The protocol was first drafted and discussed with the panel along with the communities. The refined protocol was then handed to the monitoring teams in each plot that were to be used during the field survey. To ensure a regular monitoring and sustainability of the project activities, an umbrella committee was formed, involving a member of all monitoring teams, local leaders and conservation partners.

4.2.1.e Field-based training

Nepal has always been known to successfully engage local communities to play a vital role in conserving wildlife. However, engaging communities to support wildlife conservation activities is often challenging and takes a long time. Along with awareness programs teaching monitoring wildlife is one of the best methods to engage willing stakeholders and youth from a community to build interest in wildlife conservation. Hence, during the orientation, participants were taken to the field in order to give them a practical demonstration and training on the technical parts of monitoring. Field visit was hence conducted (where feasible) and hands-on field activity on Sherman Traps, Tube Traps and Camera Traps was performed by participants. Implementation of monitoring devices were first demonstrated by the facilitators and later conducted by participants with assistance. Where the field wasn't accessible due to long distance from the training hall, participants virtually observed their area plot and engaged in handling monitoring equipment in the hall.
Prior to leaving for the plot, the area plot was shown through Google Earth in a laptop and discussion was conducted to check if the participants could identify the shown plot. Participants were provided with a rough map sketch of their area and were asked to make a pathway from the training place to the plot.

4.2.2. Questionnaire survey

Climate change and food security are two of the most pressing challenges facing the global community today. Strengthening agricultural production system is a fundamental means of improving incomes and food security for the largest group of food insecure countries in the world (World Bank, 2007; Ravallion & Chen, 2007). Climate change has a major impact on agricultural production due to the presence of extreme weather, temperature changes, rainfall fluctuation and seasonal patterns shift. Changes and anomalies in climate become troublesome to predict planting schedule and harvesting as well as issues with harvesting and water availability arises. Impact of climate change in water resources can be even more problematic due to the diverse geographic structure of Nepal, as the study in easter Terai (Regmi, 2007) showed that farmers faced a rain deficit in the years 2005 and 2006 because of an early monsoon, reducing the crop production by 12.5% nationwide. The same year, the midwestern Terai faced heavy rain, resulting in flooding and reducing production by 30%. Winter drought on the other hand has been assessed and confirmed that major winter crops like wheat and barley decreased nationally in 2009 by 14.5% and 17.3% respectively (FAO, 2008). Although there are limited adaptation methods in Nepal's agricultural sector, local communities are expected to utilize certain traditional adaptation measures to cope with the adversity of climatic variability.

A questionnaire is a research instrument consisting of a series of questions for the purpose of gathering information from respondents. They provide a quick and efficient way of obtaining a large amount of information from a large scale of people. Data can be collected relatively quickly and can be extremely useful for large populations when interviews would be impractical.

The main objective of the study was to briefly understand the climate change experiences faced by farmers in the permanent plots and understand how it has affected their day to day livelihood. Questions focused on what type of crops they used for their daily livelihood and if any recent natural calamities had affected their crops in any major ways. The questionnaire part of the study hence is to understand the impacts climate change has had in the agricultural areas of the permanent plots and has there been any adaptive alternative the locals used to tackle climatic variabilities.

The questionnaires were created and provided by WWF-Nepal prior to field work. Team members were oriented in regards to the questions dealt and basic ethics to conducting the survey. Each plot had a different questionnaire survey based on the type of major crop used in the area.

The survey was conducted from December to January 2020. Adult household members or household heads were considered for the survey. Prior verbal consent was obtained from each respondent for the questionnaire and the interview. Each interview lasted an average of 30 minutes. Surveys were carried out in Nepali language and were administered by project team members.

4.3. Results and Discussions

4.3.1. Participants

Due to extreme weather conditions, one plot (Bhena) had moved their village and school to avoid the winter. Hence, the training in that plot wasn't possible. Despite that, altogether 189 local people participated in the capacity building training in the total of 11 plots. Among them, 108 were male and 81 were female participants representing their communities (Figure 33, 34). Details to the demography in each plot has been outlined in the graph. As shown, each plot experienced more participants than expected and this can be considered as a positive sign for the local communities' willingness to learn and involve themselves within the project. Previous activities that were conducted in the plots had left the participants curious and this project remarked as a second phase to what they had experienced earlier, creating more expectations from the participants.

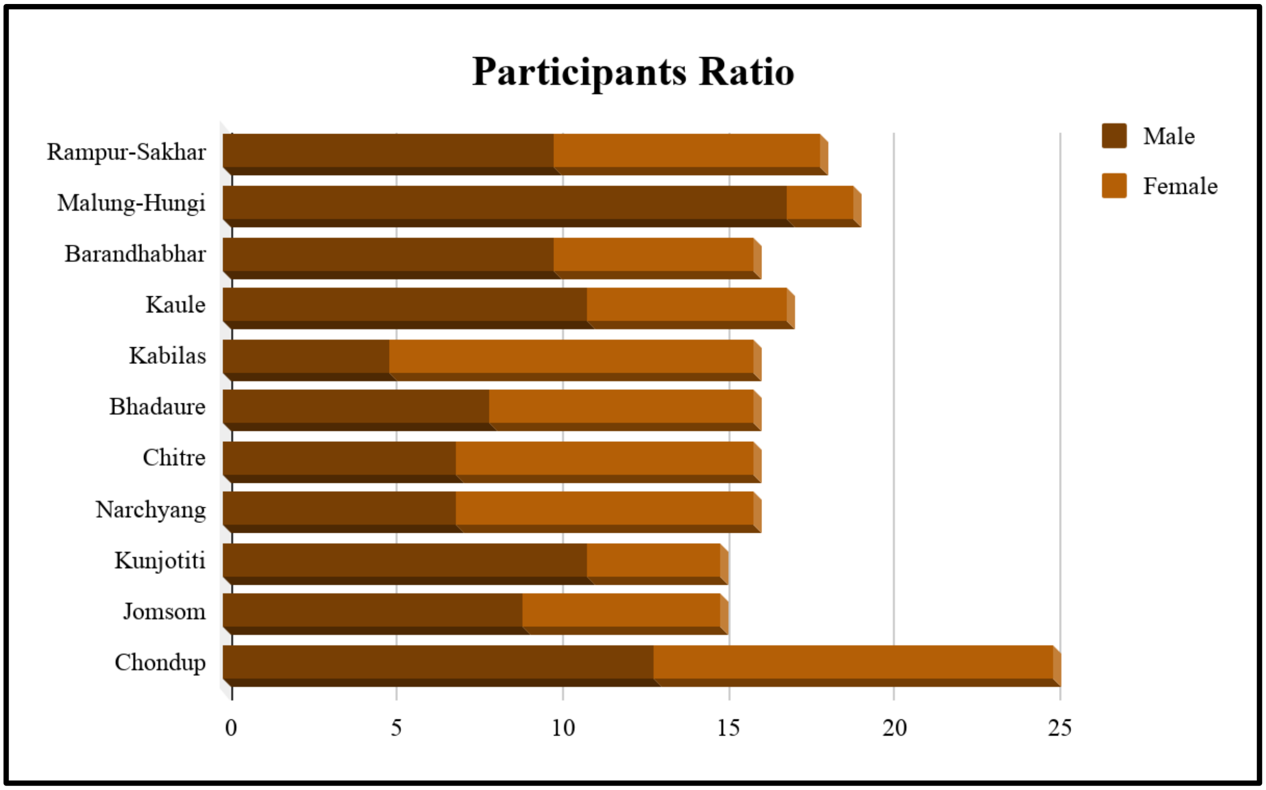


Figure 35: Ratio of participants in all plots

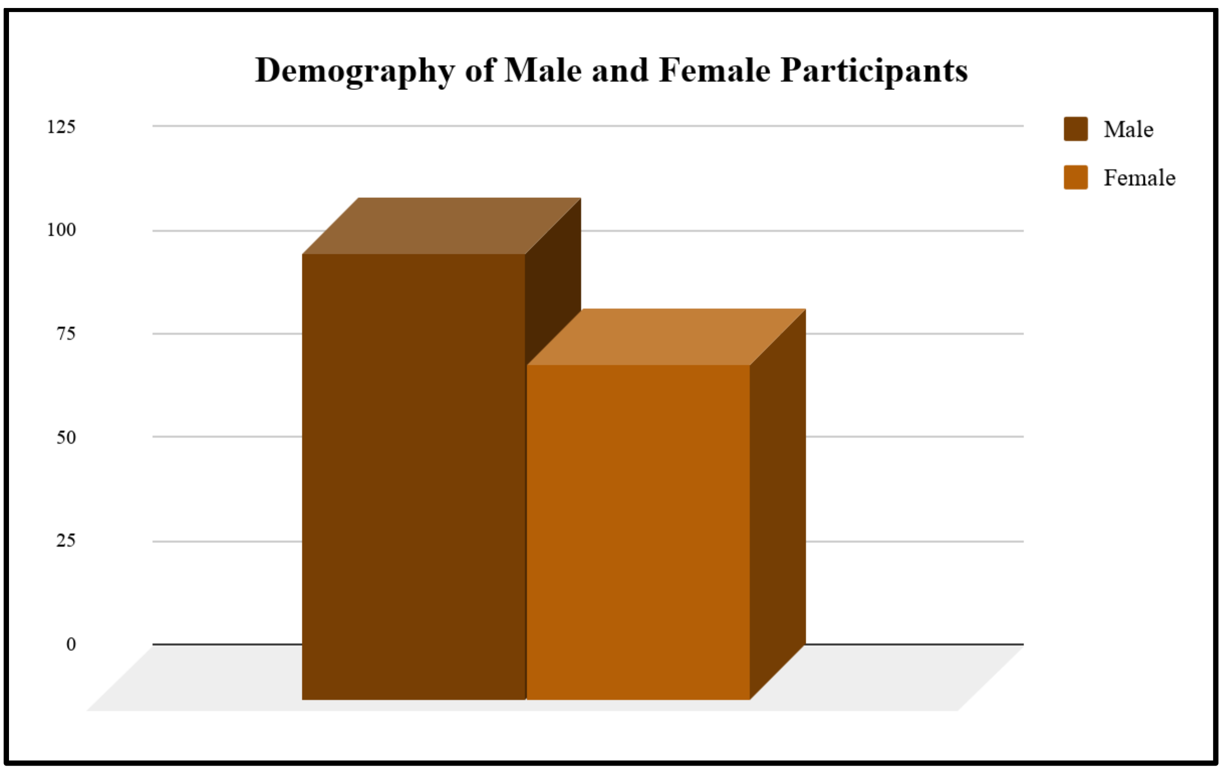


Figure 36: Gender ratio of participants

4.3.2 Activities

Unfortunately, some of the schools were extremely far in distance from the plot that was planned to be surveyed during the training session. Hence, instead of taking the participants to the plot, Google Earth was used to demonstrate the plot and ways the project team members had been monitoring through various different equipment and techniques. This happened to be more than effective since the idea of seeing a plot on the screen of a computer wasn't fathomable to many local participants. Watching their local neighborhood through satellite image was found to have fascinated the participants and where feasible, this activity was repeated in different plots. Participants also discussed different pathways to get to the plot in order to ensure that they are familiar to the monitoring plots.

4.3.3 Climate

From the discussions conducted, all the 12 plot participants happened to have experienced changes in climate in different ways. In the higher altitude plots, it was mentioned that snow fall seasons had been changing slowly in the area, causing seasonal variation locally and significant decrease of snow in the mountains were experienced. Snow covers had also drastically decreased and it was estimated that alternate years of snowfall could be one of the reasons for this reduction. For instance, if the area had heavy snowfall in a year, the year after experienced very less snow. In Narchyang, locals expressed their concern that due to untimely melting of snow, the mountain ranges had lost their charm significantly. In fact, in the past 15 years, 20 meters of the peaks' glaciers had reduced.

Rain patterns had also changed, with precipitation increased in all the plots. Winter rainfall in particular, that used to be rare before, was seen to be much more common. This has speculated to contribute to major flash floods experienced by different project plots. For instance, the Tiri lake in Jomsom overflowed due to a significant disaster when the Glacier Lake outburst occured in 2071 B.S. On the contrary, hailstones that used to occur in the past were known to have stopped in some areas.

Jomsom plot locals confirmed that there had been no hailstones for the last three consecutive years.

Drinking water was another issue the questionnaire was developed to explore and most of the water sources in the plots were found to have dried up, mostly or completely depending on the area and the local publics had shifted their usual water source to another natural spring. In the Terai region, constructions were causing shortage of drinking water.

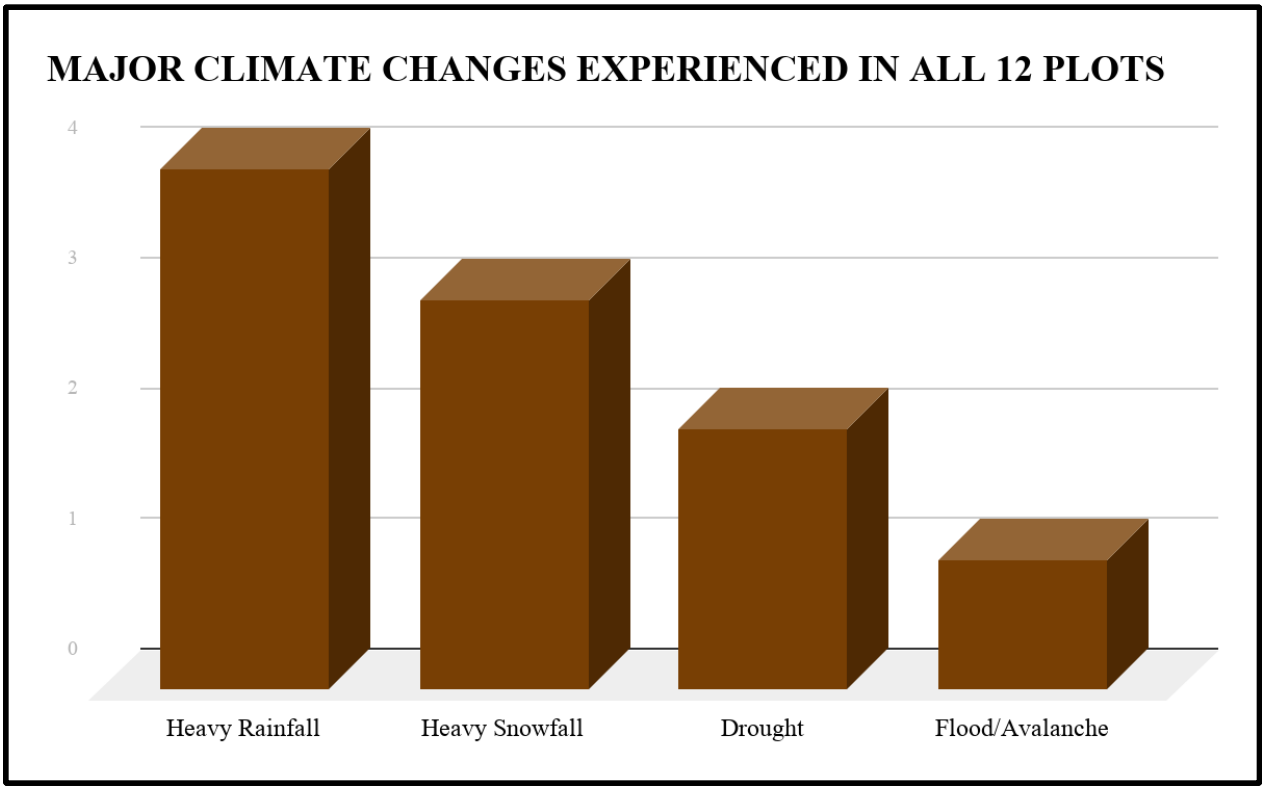


Figure 37: Impacts of cc in all plots

4.3.4 Crops

The questionnaires were conducted among adults whose primary source of income was their crops and agriculture in order to understand the loss and damage they have experienced through climate change in weather and the environment. Over the course of time, the majority of the farmers interviewed mentioned that they had experienced climate changes which had caused damages in their crops as well. Locals in Narchyang village pointed out that uncertain snow falls in the higher region was recorded to have caused pest problems and disease infections in the crops, eventually leading to reduction in the crop yield. In the Terai region, Armyworm (also known as fauji kira) were known to damage whatever remaining of the crops that the farmers were able to save from hailstorms.

The change in climate was also slowly bringing changes in the types of crops they planted in their area. In Jomsom for instance, it is reported to have imported Indian bdellium (*Commiphora wightii*) and *Vachellia nilotaca* to expand their market in the area according to the changing weather. In Bhadaure however, this has affected the crop patterns and eventually changing the harvesting season as well. Rhododendrons that were known to flower in the months of Falgun and Chaitra were now flowering in Mangsir. In Kabilas, locals discussed how the flowering season was drastically changing for some significant flowers like Marigolds that are essential for Dashain and Tihar festivals. Usually flowering till Kartik, the participants relayed that they still had the flower to be sprouting in mid-winter season as well (i.e. Poush). In Kunjotiti, farmers extended their concern on how their apple farming was no longer suitable for the hotter weather and they were obliged to take a different farming alternative into accounts.

However it has not been only climate that has caused extensive decrease in crops and wild plants as in Jomsom, locals informed that bushes of Seabuck thorns (*Hippophae rhamdoides*), Apricot (*Prunes armenaca*), Pine (*Populus ciliata*), *Jharsing, Tangsho* had significantly decreased due to construction of roads.

Table 19: Major type of plants and crops found in the plot (As derived by WWF-Nepal provided questionnaire)

Plot	Types of Crop Grown
Chhonhup	Wheat, Naked Barley, Millet, Potato
Bhena	
Jomsom	
Kunjo-Titi	
Narchyang	Maize, Wheat, Barley, Rice
Bhadaure-Chitre	
Harpankot-Kaski	
Kabilas	Maize, Wheat, Barley, Mustard
Kaule	Rice, Wheat, Maize, Mustard
Barandabhar	
Malung-Hungi	
Rampur-Sakhar	

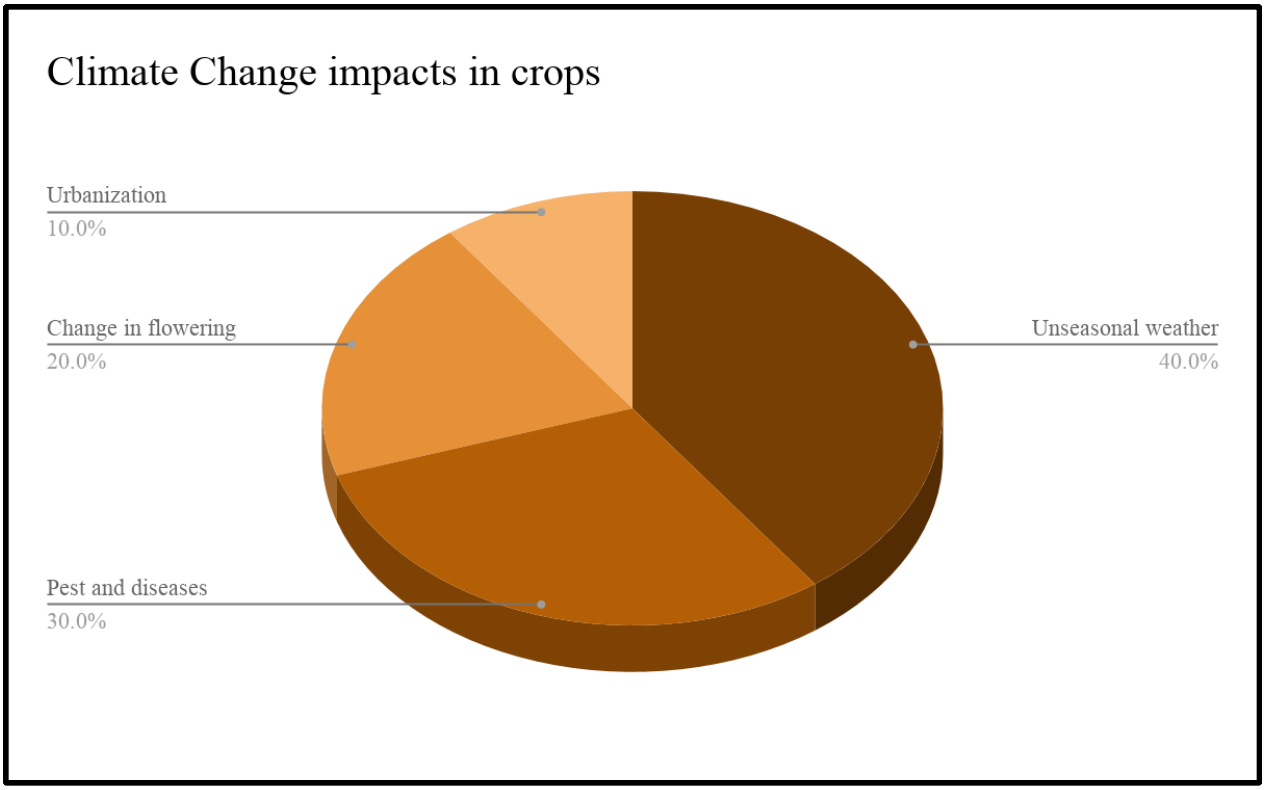


Figure 38: climate change impacts in crop

4.3.5 Catastrophe

Most of the plots have had a history of experiencing devastating natural catastrophes in the past that were slowly increasing. Melting of ice caps in the higher altitude have mostly caused natural disasters like avalanches, causing extensive damages in many nearby villages. Thunderstorms in Bhadaure have been recorded to have caused death and property damages in the previous year as well. Days were noted to have become hotter than it used to be in summer while winter had grown significantly colder. In fact, natural disasters like drought and forest fires were reported in some of the plots.

However, it was also mentioned that people have reduced practicing collection to medicinal herbs (*Dactylorhiza hatagirea*, musk roots) and have started cultivating crops like naked barley, beans, maize and barley instead. This is a positive sign of the locals becoming more aware of the endangered species and using alternatives for economic resources.

4.4. Conclusion

Encouraging school students and local community stakeholders can be an essential part of conservation and long-term monitoring of the climate change vulnerable species. Especially, due to the long time length for monitoring any species, by engaging local people to monitor the species would not only be economically efficient, but also a highly motivating factor to create environmentally aware citizen scientists in remote areas as well. By including enthusiastic individuals and providing some of the monitoring equipment like binoculars and GPS could further enhance and encourage their enthusiasm for frequent visits in the plot areas. Furthermore, providing necessary training for local people in the community can be seen as a significant step to collect more, in depth data in different seasons which is ultimately bound to benefit the overall conservation of biodiversity.

On the other hand, it was also discovered that whether it was in the higher altitudes or the Terai plains, significant amounts of impacts could be seen due to climate change in the local communities and there seemed to have had little alternative done for the impacts. Exploration of the livelihood impacts on local communities was done via questionnaire survey with the local people and results discussed earlier shows that not only wildlife and biodiversity, but the local communities and their agricultural incentives were being affected due to the climatic variability. As it was discovered through the species vulnerability assessment that climate change could be one another factor (after anthropogenic factors) to enhance human-wildlife conflicts, pressure in crops for the local communities from climate disasters could be increased if conflict with animals also rises. This could further lead to killing of some endangered and vulnerable species like Snow Leopards and Himalayan Black Bear that are noted to travel towards human settlements for food. Hence, enhancing conservation activities like biodiversity monitoring and wildlife conservation in a local level where such conflicts via climate change is a possibility is absolutely necessary to create balance between both human communities and the wildlife.

5. Area of Support for Long Term Monitoring

5.1 Introduction

Participation of non-experts in environmental management and monitoring is emerging as one of the most important issues since the environmental movement of the 1960-70s (Kenney 2001). Engaging local people is crucial for the success of a conservation program; they have the best knowledge of their forests and wildlife. Therefore involving these communities from the outset, by having them physically collect information, builds ownership of the species and their forests (Williams et al., 2011). Participation in citizen science programs can contribute towards decision making processes by governments, companies and institutions (Sinclair and Diduck 2001) and ensures a better understanding of key issues by different stakeholders (Conrad 2006, Cooper et al. 2007, Ely 2008, Haywood and Besley 2014). Public Engagement in community based monitoring programs help local users to build the perception that a forest can be of longer-term benefit if used sustainably, and to appreciate the inherent aesthetic value of natural ecosystems and the wildlife species (MoFSC 2015). Recent citizen science projects on biodiversity, ecosystems functioning, species distribution, water, and soil and air quality have shown that productive partnerships between scientists and the public can be formed (Thornhill et al. 2016). When a community takes the responsibility to collect data on their local environment, citizen science can be denoted as community-based monitoring (Conrad and Hilchey 2011). Despite such conceptual differences, volunteer participation in environmental monitoring, as citizen science or community-based monitoring, is increasing in practice (Au et al. 2000, Conrad 2006, Couvet et al. 2008).

Identifying the right local people for the programme is one of the keys for the successful citizen science project (Cunha et al., 2017). For the long term monitoring involvement of the local communities is crucial. Citizen scientist project was has been stated by many organisation and good example is Red Panda conservation in the eastern Nepal where through the community-based monitoring program, cattle headers who responsible for many anthropogenic threat to Red panda and its habitat has become the protector or supporter of the species (Williams et al., 2011). However, proper training and orientation as well as necessary equipment should be provided to these communities before they engage in collecting data.

5.2 Methods

Informal discussion was carried out with local knowledgeable people and school teachers who had been involved in the WWF training previously. The informal discussion was focused on the best way to sustain the long term local level monitoring mechanism, area of support to carry out monitoring as well as their concern and perception regarding the permanent plots. Moreover, expert level discussion was carried out among the project staff and experts of SMCRF to know the area of support at the local level.

5.3 Result and Discussion

5.3.1 Capacity Building

- Wildlife Monitoring Training: There was limited conservation knowledge among the local people and students in each plot. Conservation awareness of these plots should be accomplished by detailed training on biodiversity monitoring. Moreover, these training should include the general introduction, ecology, conservation threats and importance as well as monitoring techniques and recording data for key indicator species. These training or awareness activities should be done periodically.
- Although encouraging school students to participate in training can be a motivating factor for youth in the community, many students were known to leave the place once their education is completed. This brings a gap in the

participants who are being trained. To bridge the gap, it is best to involve more local communities and fewer school students (from Grade 7-9) for training workshops.

- Questionnaires focusing on the livelihood vulnerability index in the future could be extremely important in analyzing how climate change and wildlife conflicts have been affecting the local people's lives. A regular survey in a measured time difference could provide functional information for future references.

5.3.2 Resources

- Though the community were intrigued in learning more about biodiversity assessment, providing sufficient monitoring equipment to each group GPS, camera, binoculars, measuring tape, DBH tape, first aid kit, notebooks, pens for the local community could further enhance and encourage their enthusiasm for frequent visits in the area plots.

- A pictorial booklet on the overall biodiversity of each plot and monitoring protocol for indicator flora and fauna should be provided to each plot.
- Collaboration should be done with the local bodies (Municipality or Rural municipality) to ensure the necessary cost required or seed funds can be provided in each survey group to do monitoring these plots.

5.3.3 Monitoring techniques

- Some schools were chosen far from the plots (as per the recommendation) although in few locations the school is located within the plots. Involving the school and communities nearby plot would be beneficial for long-term monitoring and participants will be eager to learn.
- A climate data logger could be extremely useful for monitoring local climatic patterns and helpful for long-term climate monitoring in each plot. Some of the

locations had good potential to bring out even better data if camera traps were installed throughout a whole year.

- For better data and consistency, surveys should be replicated at the same date on each plot following the monitoring protocol and for mammals, camera traps should be fixed at the same location.
- Data could be far better if the surveys are done two times a year in winter and summer or at least in every two years.

5.4 Conclusion

Although local people (local monitoring group) have limited conservation knowledge their interest towards conservation of flora and fauna is huge so conservation awareness programme and detailed training on monitoring protocol on surveying the indicator species is necessary. These groups should be supplemented by the sufficient monitoring equipment. Moreover, providing a pictorial book or booklet of overall biodiversity of each plot will helpful for local and local people to understand their biodiversity. Setting a data logger, or putting camera traps around the year in some places will gives the huge information about the species and regular monitoring should be done two times a year in winter and summer or at least in every two years.

6. Temperature and Precipitation around the Monitoring Plots

6.1 Introduction

Temperature and precipitation are the two major indicators of climate change. Many studies conducted in the context of Nepal's past climatic scenarios have proved significant warming trends particularly in recent decades (Shrestha and Nepal, 2016). The model from the Coupled Model Intercomparison Project, Phase 5 (CMIP5) also predicts that the mean annual temperature is to increase from 1.3 degrees to 3.8 degrees by 2060 (World Bank, 2019). Similarly contemplating World Bank's projection, Timsina (2011), exemplifies that temperature levels in western and central Nepal are expected to increase at a higher rate as compared to eastern Nepal. Nepal's most observed climate change impacts are temperature increase, erratic rainfall, unpredictable monsoon seasons, increased occurrence of storms, landslides, and droughts (Khanal, 2014). A national adaptation plan report published by the Ministry of Forest and Environment in February 2019 delineates that Nepal has been warming by about 0.6 degree Celsius per decade between 1975 and 2005 which is three times as high as the global average. The prediction made by Global Circulation Model shows 11-28 percent increase in the frequency of hot days, and 18-28 percent increase in hot nights (Practical Action, 2010).

Climate change has emerged as the major concern in the Himalayas as the rate of increase in temperature is significantly higher than global average (IPCC, 2007). Nepal lies in the central Himalaya and has been rated as the fourth most vulnerable country to Climate Change (Maplecroft, 2011). The fragile ecosystems, unstable geology and complex topographies of Mountain Countries like Nepal are susceptible to Climate Change effects (Barry 1990). Based on temperature observation in Nepal from 1977, a warming trend increasing with altitude is concluded (Shrestha et al. 1999) and increase in the frequency of high intensity rainfall, leading to more flash floods and landslides, has been reported (Chalise and Khanal, 2001 and ICIMOD, 2007). Fluctuation in river flows, increase in number of flash floods and flood days, has been evident examples of climate change in Nepal (Shakya, 2003). Not only this, but various climate models have predicted significant increase in temperature and annual precipitation rate in the years 2030, 2050 and 2100 (Agrawala et al., 2003).

6.2. Methods

The set of data for both temperature and precipitation were obtained from the gridded Climatic Research Unit (CRU) Time-Series (TS) data set of version 4.03 data produced by CRU at University of East Anglia at the high resolution of (0.5*0.5) grids. The CRU repository consists of the temperature and precipitation data sets from January 1901- December 2018 AD. Basically these data sets, CRU TS 4.03, are produced using angular-distance weighting (ADW) interpolation method. These data are the monthly gridded fields based on monthly observational data calculated from daily or sub-daily data by National Meteorological Services and other external agents.

For our study, we extract the data based on the gps at each station. We set up our coordinates. Based on the available coordinates, we extracted the yearly value of temperature and precipitation. The yearly value data from 1900 to 2018 were extracted from CRU TS 4.03. Later, the yearly average value of these two data sets were calculated in the R-software. The extracted data have the same value for two to four stations so we did further analysis on the pattern and was done using excel only for six stations. These six stations were a) Chhondup b) Bhena_Jomsom_kunjo_Titi c) Bhadaure_harpandkot d) Aserdi-malung_Rampur e) Kabilash and Kaule and f) Barandabhar.

6.3. Result and Discussion

6.3.1 Chhonhup

The temperature in Chhonhup gradually increased from -4.38 degree celsius at the beginning of 1970 to -3.2 at the end of 2018 (Figure 37). It shows that, in the past 50 years temperature in the Chhondup increased by 1.18 degrees. Comparing pre and past 2000 data, the curve started to rise more after 2000 compared pre 2000 data. The highest annual mean temperature (-2.67degree Celsius) was recorded in 2016 while lowest annual mean temperature (-4.7 degree Celsius) was recorded in 1972. Overall, average annual temperature was recorded -3.73 degree Celsius in between 1970s and 2018.

Looking at the precipitation data of Chhondup from 1970 to 2018, the precipitation curve looks stable although fluctuation was observed in different years. Major drop in precipitation was observed in 1992 (53.70mm) while highest precipitation (79.51mm) was recorded in 1996. Overall annual average precipitation was recorded 66.96 mm in the plot (Figure 38).

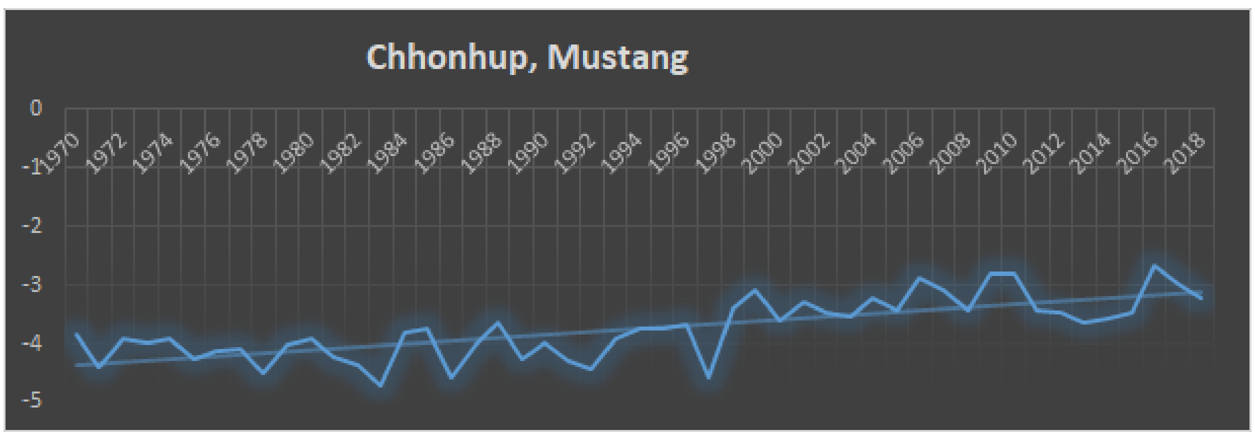


Figure 39: Temperature pattern of Chhondup area from 1970-2018

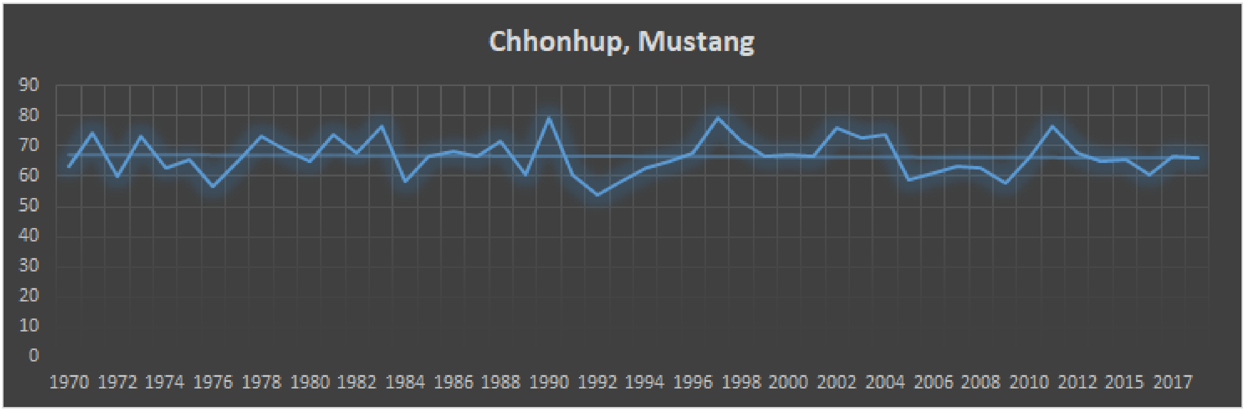


Figure 40: Precipitation pattern of Chhondup area from 1970-2017

6.3.2 Bhena_Jomsom_Kunjo_Narchyang

The annual mean temperature shows the fluctuations through the years with noticeable increase in the temperature since 1998. In the early 1970s, the average temperature was recorded -1.44 degree Celsius while it rose to -0.36 at the end of 2018, an overall increase of 1.08 degree Celsius. The highest annual mean temperature (-1.69 degree Celsius) was recorded in 2016 while lowest average annual temperature (0.11 degree Celsius) was recorded in 1982. Overall, average annual temperature was recorded -0.85 degree Celsius in between 1970s and 2018 (Figure 39).

The annual mean precipitation fluctuates throughout the years although the trend line seems to be steady throughout the years, a major drop in precipitation was recorded in 1992 with 58.1 mm and 91.591 mm recorded in 2011 was the highest average precipitation recorded in the area. Overall annual average precipitation was recorded 77.07mm in the plot (Figure 40).

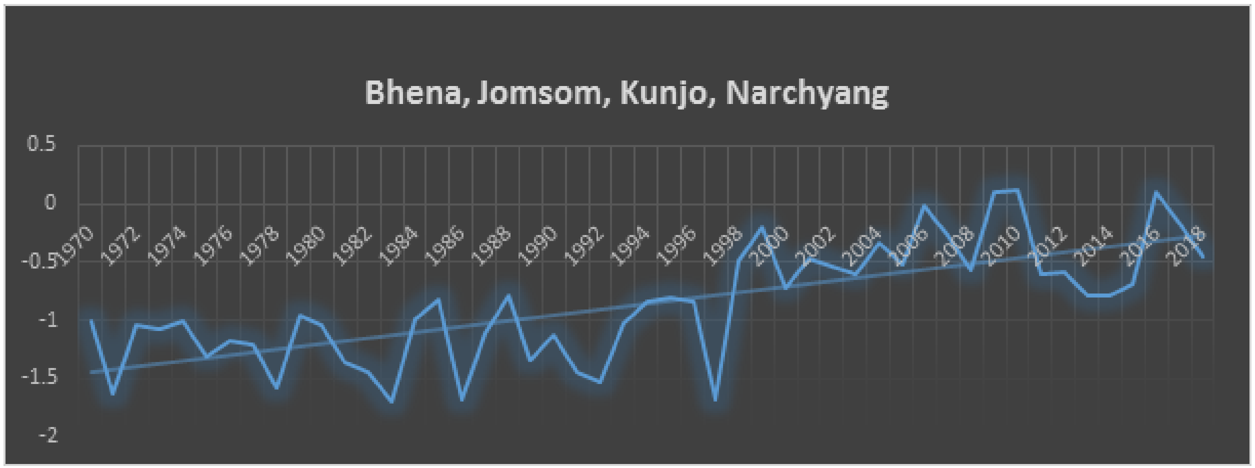


Figure 41: Temperature pattern of Bhena, Jomsom, Kunjo, Narchyang area from 1970-2018;

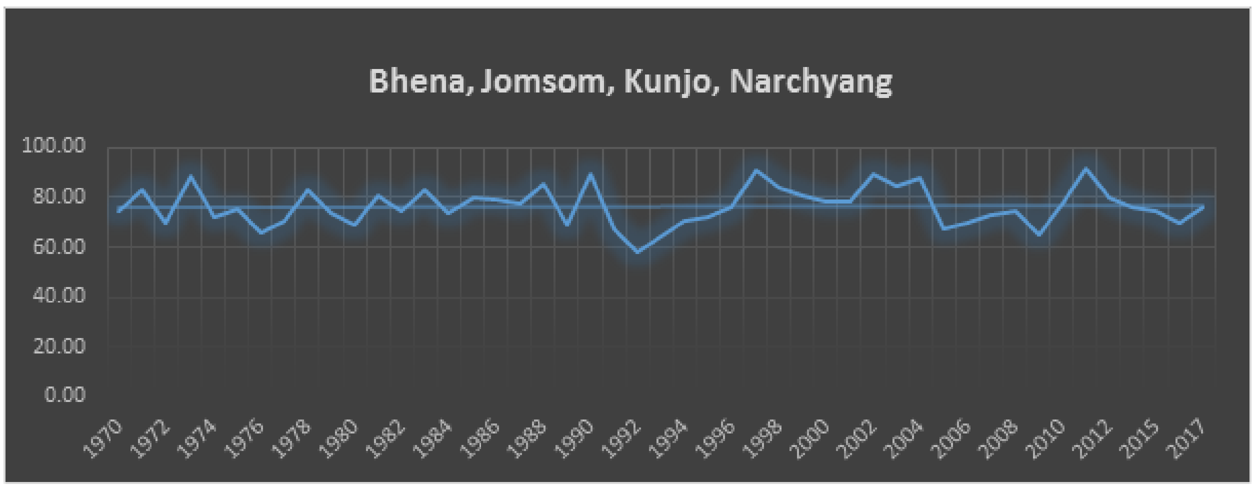


Figure 42: Precipitation pattern of Bhena, Jomsom, Kunjo, Narchyang Area from 1970-2017

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6.3.3 Bhadaure, Chitre and Harpankot

The mean temperature shows the fluctuations through the years with noticeable increase in the temperature since 1998. In the early 1970s, the average temperature was recorded 13.7 degree Celsius while it rose to 14.9 at the end of 2018, an overall increase of 1.2 degree Celsius. The highest average annual temperature (15.16 degree Celsius) was recorded in 2016 while lowest average annual temperature (13.32 degree Celsius) was recorded in 1972. Overall, average annual temperature was recorded 14.27 degree Celsius in between 1970s and 2018 (Figure 41). While annual average precipitation was steady throughout the years, a major drop in precipitation was recorded in 1992 with 98.008 mm and 172.45 mm recorded in 2011 was the highest average precipitation recorded in the area. Overall annual average precipitation was recorded 135.69mm in the plot (Figure 42).

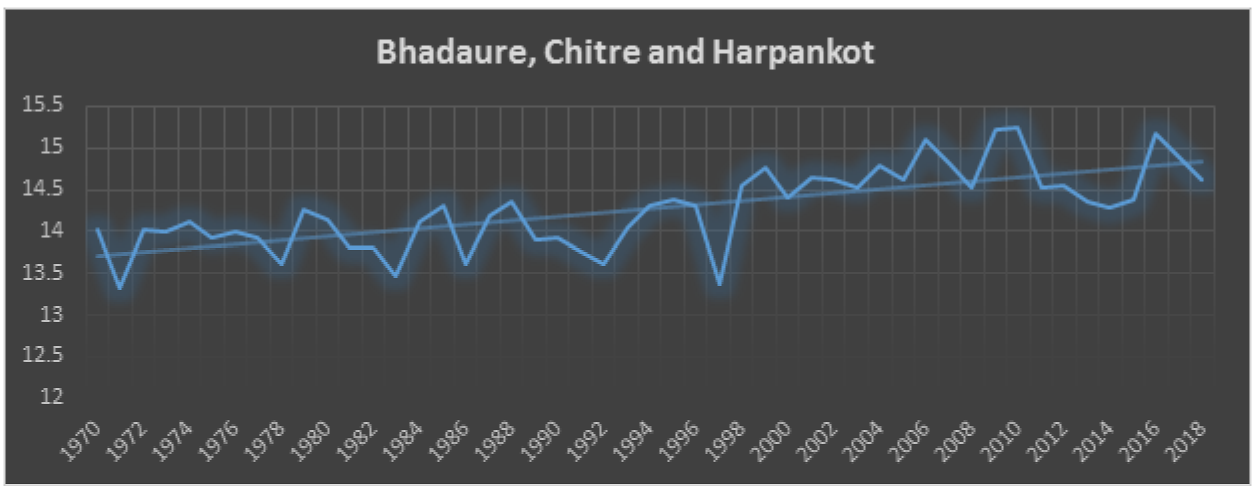

Figure 43: Temperature pattern of Bhadaure, Chitre and Harpankot plot from 1970-2018

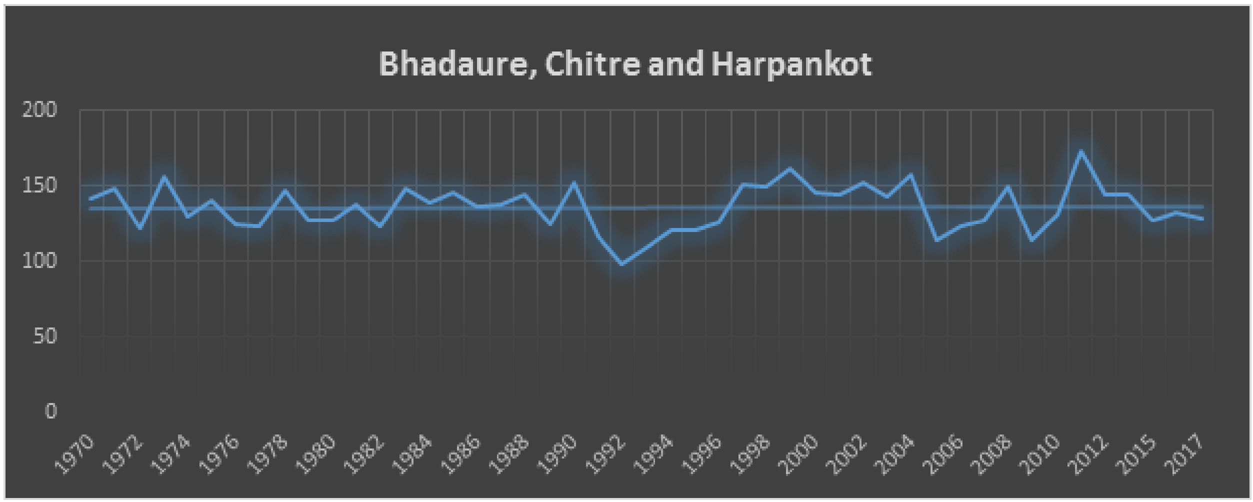

Figure 44: Precipitation pattern of Bhadaure, Chitre and Harpplot from 1970-2017

6.3.4 Asardi-malung and Rampur

The mean temperature shows the fluctuations through the years with noticeable increase in the temperature since 2000. In the early 1970s, the average temperature was recorded 22.14 degree Celsius while it rose to 23.3 at the end of 2018, an overall increase of 1.16 degree celsius. The highest average annual temperature (23.65 degree Celsius) was recorded in 2010 while lowest average annual temperature (21.68 degree Celsius) was recorded in 197. Overall, annual mean temperature was recorded 22.68 degree Celsius in between 1970s and 2018 (Figure 43).

The annual mean precipitation was steady throughout the years, a major drop in precipitation was recorded in 1992 with 98 mm and 131.9 mm recorded in 2011 was the highest average precipitation recorded in the area. Overall annual average precipitation was recorded 163.51mm mm in the plot (Figure 44).

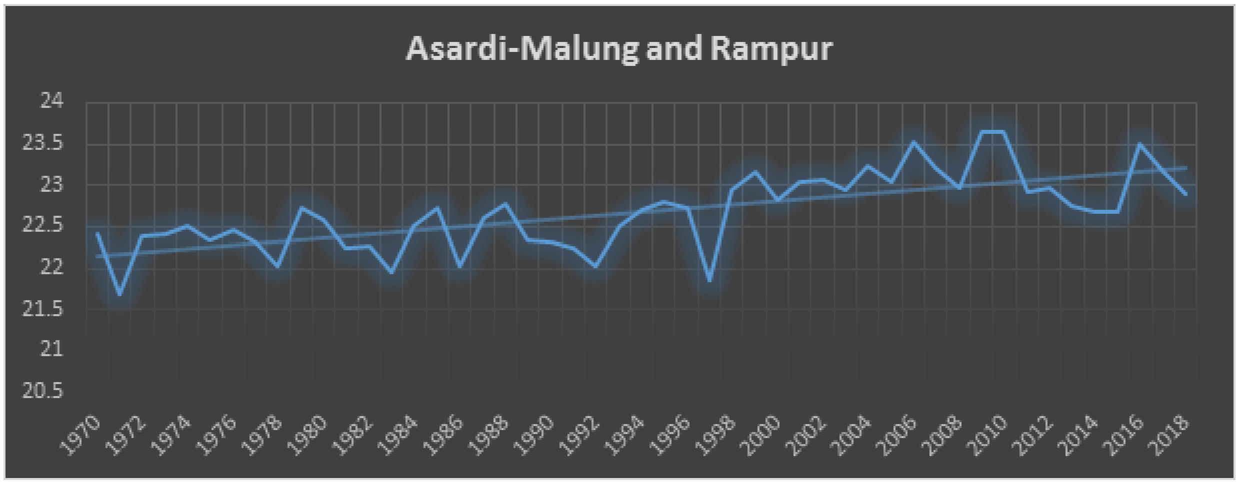

Figure 45: Temperature pattern of Asardi-Malung and Rampur plot from 1970-2018

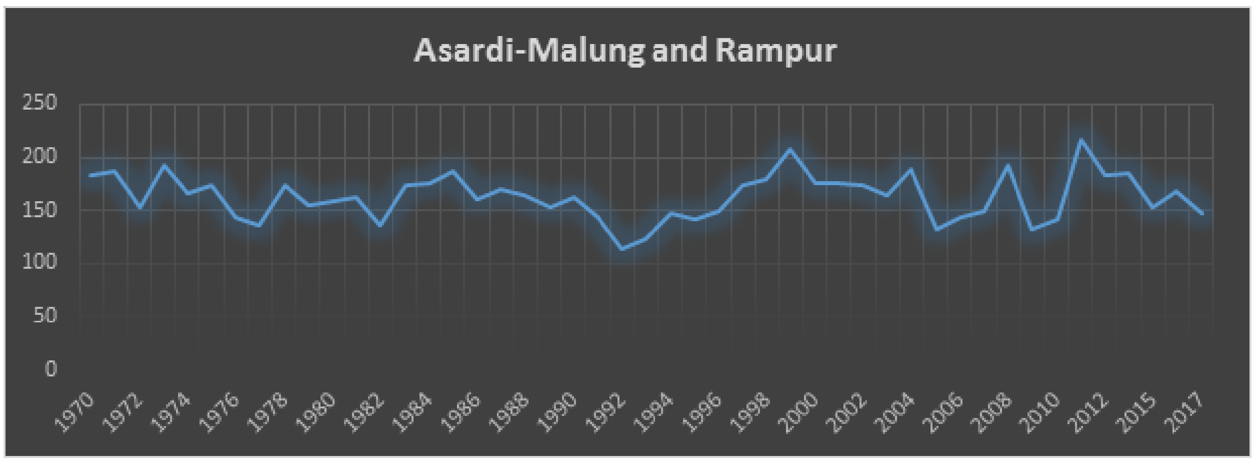

Figure 46: Precipitation pattern of Asardi-Malung and Rampur plot from 1970-2017

6.3.5 Kabilas and Kaule

The mean temperature shows the fluctuations through the years with a noticeable increase in the temperature since 2000. In the early 1970s, the mean temperature was recorded 21.95 degree Celsius while it rose to 23.1 at the end of 2018, an overall increase of 1.15 degree celsius. The highest annual mean temperature (23.54 degree Celsius) was recorded in 2009/10 while lowest average annual temperature (21.41 degree Celsius) was recorded in 1971. Overall, annual mean temperature was recorded 22.45 degree Celsius in between 1970s and 2018 (Figure 45). The annual mean precipitation was very slightly increased throughout the years, a major drop in precipitation was recorded in 1992 with 121.97 mm and 249.1 mm recorded in 2011 was the highest average precipitation recorded in the area. Overall annual mean precipitation was recorded 181.07 mm mm in the plot (Figure 46).

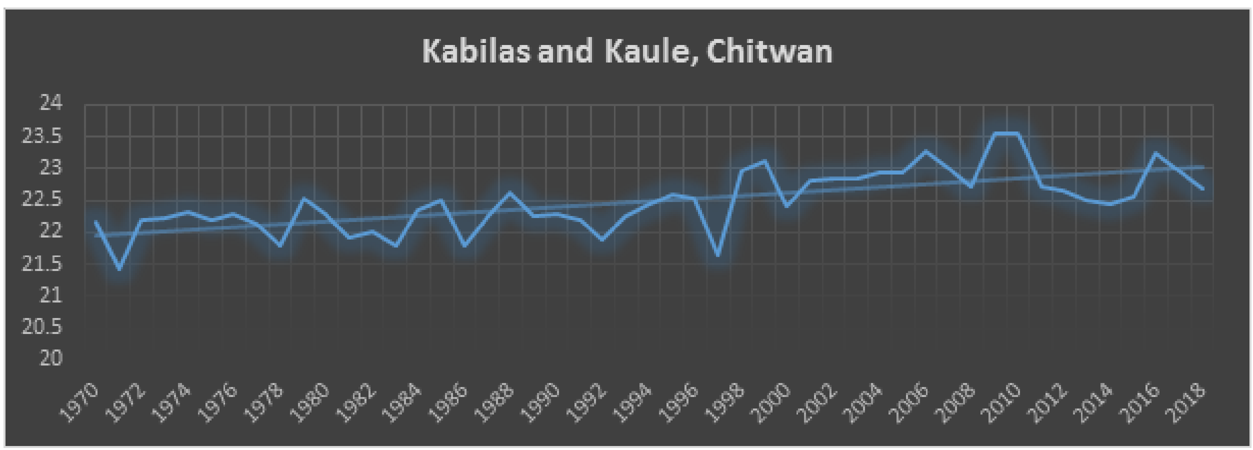

Figure 47: Temperature pattern of Kabilas and Kaule, Chitwan plot from 1970-2018

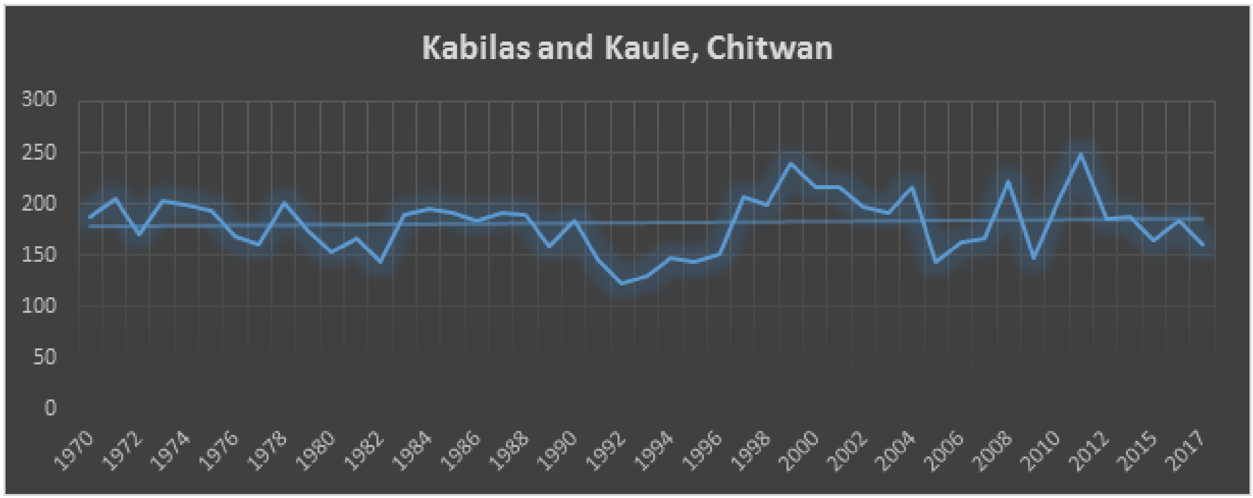

Figure 48: Precipitation pattern of Kabilas and Kaule, Chitwan plot from 1970-2017

6.3.6. Barandabhar

The mean temperature shows the fluctuations through the years with a noticeable increase in the temperature since 2000. In the early 1970s, the mean temperature was recorded 22.68 degree Celsius while it rose to 23.74 at the end of 2018, an overall increase of 1.06 degree Celsius. The highest annual mean temperature (21.21 degree Celsius) was recorded in 2010 while lowest average annual temperature (22.17 degree Celsius) was recorded in 1971. Overall, annual mean temperature was recorded 22.97 degree Celsius in between 1970s and 2018 (figure 47).

The annual mean precipitation was very slightly increased throughout the years, a major drop in precipitation was recorded in 1992 with 121.75 mm and 243.88 mm recorded in 2011 was the highest average precipitation recorded in the area. Overall annual mean precipitation was recorded 177.38 mm mm in the plot (Figure 48).

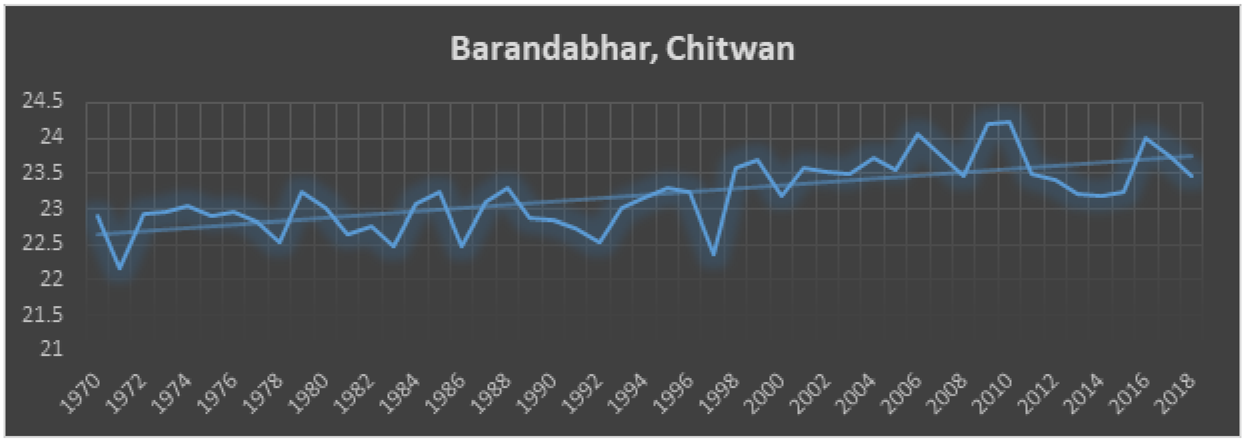

Figure 49: Temperature pattern of Barandabhar, Chitwan plot from 1970-2018

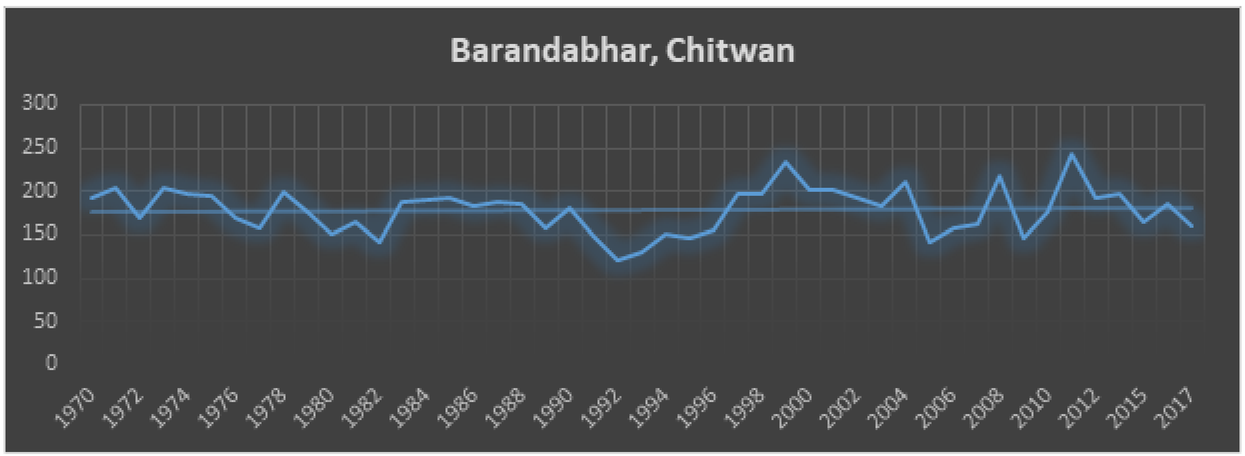

Figure 50: Precipitation pattern of Barandabhar, Chitwan plot from 1970-2017

Table 20: Temperature changing rate and annual mean temperarute of all plots

Monitoring Site	Temp change (1970-2018	Mean Yearly Temperature
Chonhup	1.18	-3.73
Bhena_Jomsom_Kunjo_Narchyang	1.08	-0.85
Bhadaure_Harpankot	1.2	14.27
Aserdi-malung_Rampur	1.16	22.68
Kabilash_Kaule	1.15	22.45
Barandabhar	1.06	22.97

6.4 Conclusion

Yearly temperature pattern in the CHAL area shows an increase in the temperature in all stations. The lowest temperature 1.06 degree Celsius rises in Barandabhar while highest in Bhaduare_Harpankot plot by 1.2 degree Celsius in the past 50 years from 2070-2018. Although temperature changes from 1.06-1.20, temperature in the last two decades was remarkable. On average in the CHAL area temperature was raised by 1.13 degree Celsius.

7. CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

Altogether 54 mammal species, 284 bird species, 107 butterfly's species and 13 herpetofauna species were identified along the 12 permanent plots in this survey. Compiling the data of the previous survey i.e. NTNC 2016, altogether 77 mammal species, 337 bird species, 232 butterfly species and 49 herpetofauna species has been recorded from the 12 monitoring plots. The survey records eight species of mammal listed as globally threatened while 12 species listed in the national threatened category. Similarly eight species of bird listed in the IUCN threatened category while 16 species listed in the national threatened category. Diversity of mammals and Birds were higher in the lower elevation plots (Barandabhar and Rampur) while fewer species were recorded from the higher altitude (Chhonhup, Bhena and Jomsom). Our mammals and bird diversity along the elevation gradient shows the general pattern of species i.e. the decline of species richness with increasing elevation.

From our study, we identified 7 species that could be climate change indicators in Nepal and potential eight species of bird are climate indicator though proper monitoring of these species in their habitat is essential. Especially for larger mammals like Asian Elephant and Greater One-horned Rhinoceros that are even more vulnerable to climate change due to their longer generation time, large body mass and freshwater requirement to combat heat from their body. That being said, it is unwise to think that some other species as Royle's Pika is less vulnerable in comparison to the larger mammals as the Royle's Pika heavily depends upon winter snow's thickness for thermoregulation. Climate change could bring an even harsher impact to these pika species if proper conservation action isn't conducted timely. Therefore, each species, large or small, must be assessed for climate change vulnerability in order to encompass global conservation of wildlife.

It was also discovered that whether it was in the higher altitudes or the Terai plains, significant amounts of impacts could be seen due to climate change in the local communities and there seemed to have had little alternative done for the impacts.

Exploration of the livelihood impacts on local communities was done via questionnaire survey with the local people and results discussed earlier shows that not only wildlife and biodiversity, but the local communities and their agricultural incentives were being affected due to the climatic variability. As it was discovered through the species vulnerability assessment that climate change could be one another factor (after anthropogenic factors) to enhance human-wildlife conflicts, pressure in crops for the local communities from climate disasters could be increased if conflict with animals also rises. This could further lead to killing of some endangered and vulnerable species like Snow Leopards and Himalayan Black Bear that are noted to travel towards human settlements for food. Hence, enhancing conservation activities like biodiversity monitoring and wildlife conservation in a local level where such conflicts via climate change is a possibility is absolutely necessary to create balance between both human communities and the wildlife.

In terms of temperature and precipitation, yearly temperature pattern in the CHAL area shows an increase in the temperature in all stations. The lowest temperature, 1.06 degree Celsius rises in Barandabhar while highest in Bhaduare_Harpankot plot by 1.2 degree Celsius in the past 50 years from 2070-2018. Although temperature changes from 1.06-1.20, temperature in the last two decades was remarkable. On average in the CHAL area temperature was raised by 1.13 degree Celsius.

Limitations

The major limitation of the study was conducting surveys on an unfavorable season. This has definitely influenced the collected data. Seasonal environments are characterized by variations in temperature, light conditions and nutrient or water availability throughout different seasons.

Small mammals in seasonal environments experience typical annual population fluctuations with low densities over winter, an increased phase in spring, a density peak in late summer, and a decline in autumn. It is clear that surveys conducted during winter have limitations. Only a few species are available for capture with the fact that many kinds of small mammals hibernate. Further, in comparison with summer, it is also more difficult to capture those species that remain more or less active all winter (Soper, 1994). Moreover, small mammals have used a variety of strategies to adapt to seasonal environments; limiting reproduction to the most favorable time periods is one such example. Likewise, the overwintering strategies of bats includes migration (Krzanowski 1964; Strelkov 1969), hibernation (Hock 1951) and fat storage (Beer & Richards 1956; Tinkle & Patterson 1965; Ransome 1968; Daan 1973; Avery 1983). Pitfall trapping for herpetofauna and small mammals couldn't be conducted due to limited activities in these species in the winter.

Furthermore, the seasonality of the survey is found to be quite impartial for large mammals as it did not influence the data in case of low land. The record of One-horned Rhinoceros and Tiger along with other four species in the camera trap within just 3 days of camera trapping exemplifies it.

During winter, grass species accounted for 45% of the diet of One-horned Rhinoceros, aquatic plants, 18% and the rest of the diet consisted of woody plants, climbers, shrubs and tree species and therefore, One-horned Rhinoceros seek thermal cover in woodland and do not emerge till the late morning hours. While in the case of Bengal Tiger, the breeding peaks during winter (October-March) because the putative male-female interactions and mother-cub(s) interactions were higher in winter (Khan, 2004).

Therefore, although the seasonality of the survey was not favorable for small mammals, it seems to be favorable for the large mammals in the lowland. The less capture of rodents and bats while the record of camera trap of Tiger and Rhino in regards to the size of species illustrates that the timing of the survey was both favorable and unfavorable.

Another limitation for the project was the inability to include past participants for capacity development and monitoring programs. This was due to a large gap between the pilot project and the follow up project as many previous participants had moved out of their areas or the students previously involved had passed out of their classes. Hence, this was another major drawback for the project to run successfully.

Other limitations like the following should also be taken into account:

- All information presented in the report was with the survey grids and based on the primary data source excluding the local information.
- Surveys couldn't be that replicated on the exact time due to complications of time and budget constraints.
- Due to lack of camera trapping stations, current camera trapping had to be placed based on the sampling strategies.

Recommendation

Based on our studies, we have listed the following recommendation:

- As it has been frequently highlighted that South and Southeast Asia are projected to get warmer and experience extreme heat events, species in general are already experiencing such phenomena in their habitat. Understanding the impacts of such climatic variability to species and identifying climate vulnerable species can play a vital role in developing effective biodiversity conservation plans. By assessing the species' sensitivity, adaptive capacity and exposure to climatic variability, it becomes more smoother to determine which species in which habitat and regions are most at risk from climate change.
- Encouraging school students and local community stakeholders can be an essential part of conservation and long-term monitoring of the climate change vulnerable species. Especially, due to the long time length for monitoring any species, by engaging local people to monitor the species would not only be economically efficient, but also a highly motivating factor to create environmentally aware citizen scientists in remote areas as well. By including enthusiastic individuals and providing some of the monitoring equipment like binoculars and GPS could further enhance and encourage their enthusiasm for frequent visits in the plot areas. Furthermore, providing necessary training for local people in the community can be seen as a significant step to collect more, in depth data in different seasons which is ultimately bound to benefit the overall conservation of biodiversity.
- Some participants weren't able to visit the site during the workshop as the participating local schools were far from the plot. Involving nearby schools would be beneficial for participants eager to learn.
- Although encouraging school students to participate in training can be a motivating factor for youth in the community, many students were known to leave the place once their education is completed. This brings a gap in the participants who are being trained. To bridge the gap, it is best to involve more

local communities and fewer school students (from Grade 7-9) for training workshops.

- Although local people (local monitoring groups) have limited conservation knowledge their interest towards conservation of flora and fauna is huge so conservation awareness programmes and detailed training on monitoring protocol on surveying the indicator species is necessary. These groups should be supplemented by the sufficient monitoring equipment. Moreover, providing a pictorial book or booklet of overall biodiversity of each plot will be helpful for local and local people to understand their biodiversity. Setting a data logger, or putting camera traps around the year in some places will give the huge information about the species and regular monitoring should be done two times a year in winter and summer or at least in every two years.
- It is best to have the same kind of study in the future as well to not only monitor the technical parts of the project i.e. the temperature and precipitation, flora and fauna; but by continuing the monitoring part, it will be an encouragement for local stakeholders and people to be keen on conservation.
- Collaboration should be done with the local bodies (Municipality or Rural municipality) as well as state as well as national governmental bodies to ensure the necessary cost required for long-term monitoring. Seed funds should be provided in each survey group to support the regular monitoring in these plots.

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Annex

Annex 1. Mammal's species recorded in each plots

S.N.	Common Name	Chhonh up	Bhena	Jom som	Kunjo	Narch yang	Kaule	Bhad aure	Kabi lash	Harp ankot	Asardi-Malung	Ram pur	Baran dabar	Species
1	Woolly Hare	1	0	0	0	0	0	0	0	0	0	0	0	1
2	Royle's Pika	1	0	0	0	0	0	0	0	0	0	0	0	1
3	Fawn Coloured Mouse	1	0	0	0	0	0	0	0	0	0	0	0	1
4	Himalayan Field Mouse	0	1	0	0	0	0	1	0	0	0	0	0	2
5	House Mouse	0	1	0	1	0	0	0	0	1	0	0	1	4
6	Blue Sheep	0	1	0	0	0	0	0	0	0	0	0	0	1
7	Snow Leopard	0	1	0	0	0	0	0	0	0	0	0	0	1
8	Leopard	0	0	1	1	1	0	1	1	1	1	0	0	7
9	Red Fox	0	0	1	0	0	0	0	0	0	0	0	0	1
10	Himalayan Rat	0	0	1	0	0	0	0	0	0	0	0	0	1
11	Grey Shrew	0	0	1	0	0	0	0	0	0	0	0	0	1
12	Himalayan Field Rat	0	0	1	0	0	0	0	0	1	0	0	0	2
13	Barking Deer	0	0	0	1	1	0	1	0	1	1	1	1	7
14	Golden Jackal	0	0	0	1	0	1	0	1	0	1	1	1	6
15	Himalayan Goral	0	0	0	1	1	0	0	0	0	0	0	0	2
16	Himalayan Crestless	0	0	0	1	0	0	0	0	0	0	0	0	1
17	Ward's Field Mouse	0	0	0	1	1	0	0	0	0	0	0	0	2
18	Orange-bellied Himalayan	0	0	0	0	1	0	0	0	0	0	0	0	1
19	Pearson's Horseshoe Bat	0	0	0	0	1	0	0	0	0	0	0	0	1
20	Himalayan Black Bear	0	0	0	0	1	0	0	0	0	0	0	0	1

21	Leopard cat	0	0	0	0	1	1	1	0	1	1	1	0	6
22	Hoary-bellied Squirrel	0	0	0	0	1	1	0	1	1	1	0	0	5
23	Large indian civet	0	0	0	0	1	1	1	1	1	0	1	0	6
24	Himalayan Shrew	0	0	0	0	1	0	1	0	0	0	0	0	2
25	Chestnut White-bellied	0	0	0	0	1	0	1	0	0	0	0	0	2
26	Assam Macaque	0	0	0	0	0	0	1	0	1	0	0	0	2
27	Indian Hare	0	0	0	0	0	0	1	1	0	1	1	0	4
28	Little Himalayan Rat	0	0	0	0	0	0	1	0	0	0	0	0	1
29	Yellow-throated Marten	0	0	0	0	0	0	0	0	1	0	0	0	1
30	House Shrew	0	0	0	0	0	1	0	1	1	1	1	0	5
31	Crab-eating Mongoose	0	0	0	0	0	0	0	0	1	0	1	0	2
32	Terai Grey Langur	0	0	0	0	0	1	0	1	0	1	0	0	3
33	Red Giant Flying Squirrel	0	0	0	0	0	0	0	0	0	1	0	0	1
34	Black Rat	0	0	0	0	0	0	0	0	0	1	0	0	1
35	Rhesus Macaque	0	0	0	0	0	0	1	0	0	1	1	1	4
36	Jungle Cat	0	0	0	0	0		0	1	0	1	0	1	3
37	Masked Palm Civet	0	0	0	0	0	0	0	0	0	0	1	0	1
38	Indian Crested Porcupine	0	0	0	0	0	1	0	0	0	0	1	1	3
39	Intermediate Horseshoe	0	0	0	0	0	0	0	0	0	0	1	0	1
40	Common Bentwing Bat	0	0	0	0	0	0	0	0	0	0	1	0	1
41	Greater False Vampire	0	0	0	0	0	0	0	0	0	0	1	0	1
42	Great Roundleaf bat	0	0	0	0	0	0	0	0	0	0	1	0	1
43	Asian Palm Civet	0	0	0	0	0	1	0	1	0	0	0	1	3
44	House Rat	0	0	0	0	0	1	0	1	0	0	0	0	2
45	Indian Grey Mongoose	0	0	0	0	0	1	0	1	0	0	0	0	2
46	Leschenault's Rousette	0	0	0	0	0	1	0	1	0	0	0	0	2
47	One-horned Rhinoceros	0	0	0	0	0	0	0	0	0	0	0	1	1

48	Spotted Deer	0	0	0	0	0	0	0	0	0	0	0	1	1
49	Bengal Tiger	0	0	0	0	0	0	0	0	0	0	0	1	1
50	Small Indian Civet	0	0	0	0	0	0	0	0	0	0	0	1	1
51	Wild Boar	0	0	0	0	0	0	0	0	0	0	0	1	1
52	Asian Elephant	0	0	0	0	0	0	0	0	0	0	0	1	1
53	Sloth Bear	0	0	0	0	0	0	0	0	0	0	0	1	1
54	Sambar												1	1
	Total Species in each	3	4	5	7	12	11	11	12	11	12	14	15	

Annex 2. Mammal Species occurred in each order and family

S.N.	Order	Number of species
A	**Artiodactyla**	**5**
1	Bovidae	1
2	Caprinae	1
3	Cervidae	2
4	Suidae	1
B	**Carnivora**	**16**
5	Canidae	2
6	Felidae	5
7	Herpestidae	2
8	Mustelidae	1
9	Ursidae	2
10	Viverridae	4
C	**Chiroptera**	**7**
11	Hipposideridae	1
12	Megadermatidae	1
13	Miniopteridae	1
14	Pteropodidae	1
15	Rhinolophidae	3

D	**Eulipotyphla**	**3**
16	Soricidae	3
E	**Lagomorpha**	**3**
17	Leporidae	2
18	Ochotonidae	1
F	**Perissodactyla**	**1**
19	Rhinocerotidae	1
G	**Primates**	**3**
20	Cercopithecidae	3
H	**Proboscidea**	**1**
21	Elephantidae	1
I	**Rodentia**	**15**
22	Hystricidae	2
23	Muridae	10
24	Sciuridae	3
	Grand Total	**54**

Annex 3. Mammals in each Physiographic Region

S.N.	**Name of species/Physiological zone**	**High Mountain**	**Hill**	**Middle Mountain**	**Siwalik**	**Grand Total**
1	Asian Elephant				1	1
2	Asian Palm Civet		1		1	2
3	Assam Macaque		1			1
4	Barking Deer	1	1	1	1	4
5	Bengal Tiger				1	1
6	Black Rat		1			1
7	Blue Sheep	1				1
8	Chestnut White-bellied Rat		1	1		2
9	Common Bentwing Bat		1			1
10	Common Palm Civet		1			1

11	Crab-eating Mongoose		1			1
12	Fawn Coloured Mouse	1				1
13	Golden Jackal	1	1		1	3
14	Great Roundleaf bat		1			1
15	Greater False Vampire Bat		1			1
16	Grey Shrew	1				1
17	Himalayan Black Bear			1		1
18	Himalayan Crestless Porcupine	1				1
19	Himalayan Field Mouse	1	1			2
20	Himalayan Field Rat	1	1			2
21	Himalayan Goral	1		1		2
22	Himalayan Rat	1				1
23	Himalayan Shrew	1		1		2
24	Hoary-bellied Squirrel		1	1		2
25	House Mouse	1	1	1		3
26	House Rat		1			1
27	House Shrew		1			1
28	Indian Crested Porcupine		1		1	2
29	Indian Grey Mongoose		1			1
30	Indian Hare		1			1
31	Intermediate Horseshoe bat		1			1
32	Jungle Cat		1		1	2
33	Large Indian Civet		1	1		2
34	Leopard	1	1	1		3
35	Leopard Cat		1	1		2
36	Leschenault's rousette		1			1
37	Little Himalayan Rat		1			1
38	Masked Palm Civet		1			1
39	One-horned Rhinoceros				1	1

40	Orange-bellied Himalayan Squirrel			1		1
41	Pearson's Horseshoe Bat			1		1
42	Red Fox	1				1
43	Rhesus Macaque		1		1	2
44	Royle's Pika	1				1
45	Scuridae sps.		1			1
46	Sloth Bear				1	1
47	Small Indian Civet				1	1
48	Snow Leopard	1				1
49	Spotter Deer				1	1
50	Terai Grey Langur		1			1
51	Ward's Field Mouse			1		1
52	Wild Boar				1	1
53	Wolly Hare	1				1
54	Yellow-throated Marten		1			1
	Grand Total	**17**	**32**	**13**	**13**	75

Annex 4. Mammals Distribution according to Ecoregion:

S.N.	Species/Ecoregions	**Eastern Himalayan alpine shrub and meadows**	**Himalayan subtropical broadleaf forests**	**Himalayan subtropical pine forests**	**Terai-Duar savanna and grasslands**	**Western Himalayan alpine shrub and Meadows**	**Western Himalayan broadleaf forests**	**Grand Total**
1	Asian Elephant				1			1
2	Asian Palm Civet			1	1			2
3	Assam Macaque			1				1
4	Barking Deer	1	1	1	1		1	5
5	Bengal Tiger				1			1
6	Black Rat		1					1
7	Blue Sheep					1		1
8	Chestnut White-bellied rat			1			1	2
9	Common Bentwing Bat		1					1
10	Common Leopard		1	1			1	3

11	Common Palm Civet			1				1
12	Crab-eating Mongoose		1					1
13	Fawn Coloured Mouse					1		1
14	Golden Jackal		1	1	1		1	4
15	Great Roundleaf bat		1					1
16	Greater False Vampire Bat		1					1
17	Grey Shrew						1	1
18	Himalayan Black Bear						1	1
19	Himalayan Crestless Porcupine						1	1
20	Himalayan Field Mouse			1		1		2
21	Himalayan Field Rat			1			1	2
22	Himalayan Goral						1	1
23	Himalayan Rat						1	1
24	Himalayan Shrew	1					1	2
25	Hoary-bellied Squirrel		1	1			1	3
26	House Mouse			1		1	1	3
27	House Rat			1				1
28	House Shrew		1	1				2
29	Indian Crested Porcupine		1	1	1			3
30	Indian Grey Mongoose			1				1
31	Indian Hare		1	1				2
32	Intermediate Horseshoe bat		1					1
33	Jungle Cat		1	1	1			3
34	Large Indian Civet		1	1			1	3
35	Leopard cat		1	1			1	3
36	Leschenault's Rousette		1	1				2
37	Little Himalayan Rat			1				1
38	Masked Palm Civet		1					1
39	One-horned Rhinoceros				1			1
40	Orange-bellied Himalayan Squirrel						1	1
41	Pearson’s Horseshoe Bat						1	1

42	Red Fox						1	1
43	Rhesus Macaque		1		1			2
44	Royle's Pika					1		1
45	Scuridae sps.		1					1
46	Sloth Bear				1			1
47	Small Indian Civet				1			1
48	Snow Leopard					1		1
49	Spotted Deer				1			1
50	Terai Grey Langur		1	1				2
51	Ward's Field Mouse						1	1
52	Wild Boar				1			1
53	Wolly Hare					1		1
54	Yellow-throated Marten		1	1				2
	Grand Total	2	22	23	13	7	19	

Annex 5. Bird species recorded in each plot

S. N.	**Common Name**	**Chhonhup**	**Bhena**	**Jomsom**	**Kunjo**	**Narchyang**	**Bhadaure**	**Harpankot**	**Asardi**	**Rampur**	**Kabilas**	**Kaule**	**Baranda bhar**	**Total**
1	Rock Pigeon	1	0	0	1	0	0	0	0	0	1	0	0	3
2	Bearded Vulture	1	0	1	0	0	0	0	0	0	0	0	0	2
3	Himalayan Griffon	1	1	0	1	1	0	1	1	1	1	1	0	9
4	White-throated Dipper	1	0	0	1	0	0	0	0	0	0	0	0	2
5	Yellow-billed Chough	1	1	0	0	0	0	0	0	0	0	0	0	2
6	Red-billed Chough	1	1	0	0	0	0	0	0	0	0	0	0	2
7	Eurasian Tree Sparrow	1	0	0	0	0	0	0	1	0	0	0	0	2
8	Wallcreeper	1	0	1	1	0	0	0	1	0	0	0	0	4
9	Common Rosefinch	1	0	0	1	0	0	1	0	0	0	0	0	3
10	Oriental Turtle-Dove	1	0	0	1	1	1	0	0	1	1	1	0	7
11	Rock Bunting	1	1	1	1	0	0	0	0	0	0	0	0	4

12	Robin Accentor	1	1	0	0	0	0	0	0	0	0	0	0	2
13	Horned Lark	1	0	0	0	0	0	0	0	0	0	0	0	1
14	White-throated Redstart	1	1	1	0	0	0	0	0	0	0	0	0	3
15	Common Raven	1	0	0	0	0	0	0	0	0	0	0	0	1
16	Ground Tit	1	0	0	0	0	0	0	0	0	0	0	0	1
17	Daurian Redstart	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Chukar	0	1	1	0	0	0	0	0	0	0	0	0	2
19	Large-billed Crow	0	1	1	0	1	1	1	1	1	1	0	1	9
20	Variegated Laughingthrush	0	1	0	1	1	0	0	0	0	0	0	0	3
21	Spot-winged Grosbeak	0	1	0	0	0	0	0	0	0	0	0	0	1
22	Beautiful Rosefinch	0	1	1	0	0	0	0	0	0	0	0	0	2
23	Golden Eagle	0	1	0	0	0	0	0	0	0	0	0	0	1
24	Chestnut-crowned Bush-Warbler	0	1	0	0	0	0	0	0	0	0	0	0	1
25	Upland Buzzard	0	1	0	0	0	0	0	0	0	0	0	0	1
26	Black-lored Tit	0	1	1	1	1	1	1	1	1	1	1	0	10
27	Streaked Rosefinch	0	1	0	1	0	0	0	0	0	0	0	0	2
28	Rufous-throated Thrush	0	1	0	0	0	0	0	0	0	0	0	0	1
29	Egyptian Vulture	0	0	1	0	0	0	0	0	0	0	0	0	1
30	Great Cormorant	0	0	1	1	0	0	0	0	0	0	0	1	3
31	Black-throated Thrush	0	0	1	1	1	1	0	0	0	1	1	0	6
32	Common Kestrel	0	0	1	1	1	1	1	0	1	0	1	0	7
33	White-browed Rosefinch	0	0	1	0	0	0	0	0	0	0	0	0	1
34	House Crow	0	0	1	0	0	0	0	1	0	1	0	0	3
35	Mallard	0	0	0	1	0	0	0	0	0	0	0	0	1
36	Gadwall	0	0	0	1	0	0	0	0	0	0	0	1	2
37	Ruddy Shelduck	0	0	0	1	0	0	0	0	0	0	0	1	2
38	Alpine Swift	0	0	0	1	1	1	0	0	0	1	1	0	5
39	Snow Pigeon	0	0	0	1	0	0	0	0	0	0	0	0	1

40	Common Kestrel	0	0	0	1	1	0	0	0	0	0	0	0	2
41	Cheer Pheasant	0	0	0	1	0	0	0	0	0	0	0	0	1
42	Maroon Oriole	0	0	0	1	1	1	1	0	1	0	1	0	6
43	Common Coot	0	0	0	1	0	0	0	0	0	0	0	0	1
44	Altai Accentor	0	0	0	1	0	0	0	0	0	0	0	0	1
45	Red-headed Tit	0	0	0	1	1	1	1	0	0	0	1	0	5
46	Blue-fronted Redstart	0	0	0	1	1	1	1	0	0	0	1	0	5
47	Common Green Magpie	0	0	0	1	1	1	0	0	1	0	1	0	5
48	Blyth's Reed-Warbler	0	0	0	1	0	0	0	0	0	0	0	0	1
49	Brown Dipper	0	0	0	1	0	0	1	0	0	0	0	0	2
50	Buff-barred Warbler	0	0	0	1	0	1	0	0	0	1	1	1	5
51	Red-tailed Minla	0	0	0	1	0	0	0	0	0	0	0	0	1
52	Coal Tit	0	0	0	1	0	0	0	0	0	0	0	0	1
53	Dark-breasted Rosefinch	0	0	0	1	0	0	0	0	0	0	0	0	1
54	Green-backed Tit	0	0	0	1	1	0	0	0	1	0	1	0	4
55	Green Shrike Babbler	0	0	0	1	0	0	0	0	0	0	0	0	1
56	Grey-crested Tit	0	0	0	1	0	0	0	0	0	0	0	0	1
57	Grey-hooded Warbler	0	0	0	1	1	1	0	1	1	1	1	0	7
58	Golden Babbler	0	0	0	1	0	0	1	0	0	0	0	0	2
59	Golden Bush-Robin	0	0	0	1	0	1	0	0	0	0	0	0	2
60	Himalayan Bush-Robin	0	0	0	1	0	1	0	0	0	0	1	0	3
61	Himalayan Bulbul	0	0	0	1	1	1	1	1	1	1	1	1	9
62	Lemon-rumped Leaf-warbler	0	0	0	1	1	0	1	1	1	0	0	0	5
63	Gould's Sunbird	0	0	0	1	0	0	0	0	0	0	0	0	1
64	Olive-backed Pipit	0	0	0	1	1	1	0	0	1	0	1	1	6
65	Oriental Skylark	0	0	0	1	0	0	0	0	0	0	0	0	1

66	Pied Bushchat	0	0	0	1	1	1	0	1	1	1	0	0	6
67	Pink-browed Rosefinch	0	0	0	1	0	0	0	0	0	0	0	0	1
68	Alpine Thrush	0	0	0	1	0	0	0	0	0	0	0	0	1
69	Red-headed Bullfinch	0	0	0	1	0	0	0	0	0	0	0	0	1
70	Rosy Pipit	0	0	0	1	0	0	0	0	0	0	0	0	1
71	Rufous-vented Tit	0	0	0	1	0	0	0	0	0	0	0	0	1
72	Rufous-vented Yuhina	0	0	0	1	0	0	0	0	0	0	0	0	1
73	Rusty-flanked Treecreeper	0	0	0	1	0	0	0	0	0	0	0	0	1
74	Small Niltava	0	0	0	1	0	1	1	1	1	0	0	0	5
75	Spotted Nutcracker	0	0	0	1	1	0	0	0	0	0	0	0	2
76	Striated Prinia	0	0	0	1	1	0	0	1	0	1	1	0	5
77	Stripe-throated Yuhina	0	0	0	1	1	1	0	0	0	0	0	0	3
78	Red-throated Flycatcher	0	0	0	1	0	0	0	0	0	1	1	1	4
79	Whiskered Yuhina	0	0	0	1	1	1	0	0	0	0	1	0	4
80	White-bellied Erpornis	0	0	0	1	0	0	1	1	0	0	0	0	3
81	White-browed Bush-Robin	0	0	0	1	0	0	0	0	0	0	0	0	1
82	White-browed Fulvetta	0	0	0	1	1	1	0	0	0	0	1	0	4
83	White-collared Blackbird	0	0	0	1	0	0	0	0	0	0	0	0	1
84	White Wagtail	0	0	0	1	0	0	0	0	1	0	0	1	3
85	Northern Wren	0	0	0	1	1	0	0	0	0	0	0	0	2
86	Yellow-billed Blue Magpie	0	0	0	1	0	0	0	0	0	0	0	0	1
87	Yellow-breasted Greenfinch	0	0	0	1	0	0	0	0	0	0	0	0	1
88	Great Cormorant	0	0	0	1	0	0	0	0	0	1	1	0	3
89	Ashy Bulbul	0	0	0	1	0	0	1	0	0	0	1	0	3

90	Collared Owlet	0	0	0	0	1	0	0	0	1	0	0	0	2
91	Plumbeous Water-Redstart	0	0	0	0	1	1	1	1	1	0	0	0	5
92	House Sparrow	0	0	0	0	1	1	0	1	1	0	0	0	4
93	Oriental White-Eye	0	0	0	0	1	1	0	0	0	1	0	1	4
94	White-throated Laughingthrush	0	0	0	0	1	1	1	0	0	0	1	0	4
95	Fire-tailed Sunbird	0	0	0	0	1	0	0	0	0	1	1	0	3
96	Grey-headed Canary Flycatcher	0	0	0	0	1	1	0	1	1	0	1	0	5
97	Mountain Bulbul	0	0	0	0	1	0	1	0	0	0	1	0	3
98	Red-vented Bulbul	0	0	0	0	1	1	1	1	1	1	1	1	8
99	Grey-backed Shrike	0	0	0	0	1	0	1	1	1	1	0	0	5
100	Great Barbet	0	0	0	0	1	1	1	1	1	1	1	0	7
101	White-tailed Nuthatch	0	0	0	0	1	0	0	0	1	0	1	1	4
102	Grey Treepie	0	0	0	0	1	0	1	0	0	1	1	0	4
103	Slaty-headed Parakeet	0	0	0	0	1	1	0	0	0	1	0	0	3
104	Asian Barred Owlet	0	0	0	0	1	0	0	0	0	0	1	0	2
105	Rose-ringed Parakeet	0	0	0	0	1	1	0	0	1	0	0	0	3
106	Striated Laughingthrush	0	0	0	0	1	0	1	0	0	0	0	0	2
107	Slender-billed Scimitar Babbler	0	0	0	0	1	0	0	0	0	0	1	0	2
108	Rufous Sibia	0	0	0	0	1	0	0	0	0	0	1	0	2
109	Speckled Woodpigeon	0	0	0	0	1	1	0	0	0	0	0	0	2
110	Green-tailed Sunbird	0	0	0	0	1	0	0	1	0	0	0	0	2
111	Nepal House Martin	0	0	0	0	1	0	1	1	1	0	0	0	4
112	Yellow-browed Tit	0	0	0	0	1	0	0	0	0	0	0	0	1
113	Yellow-bellied Fairy-Fantail	0	0	0	0	1	0	0	1	0	0	0	0	2
114	Long-tailed Shrike	0	0	0	0	1	1	0	1	1	1	1	1	7
115	Striated Babbler	0	0	0	0	1	0	0	0	0	0	0	1	2
116	Bar-throated Minla	0	0	0	0	1	0	0	0	0	0	0	0	1

117	Hill Partridge	0	0	0	0	1	0	0	0	0	0	0	0	1
118	Fire-breasted Flowerpecker	0	0	0	0	1	1	0	1	0	1	1	0	5
119	Red-billed Leiothrix	0	0	0	0	1	0	0	0	0	0	0	0	1
120	Eurasian Sparrowhawk	0	0	0	0	1	0	0	0	0	0	0	0	1
121	Common Stonechat	0	0	0	0	0	1	1	0	1	0	0	1	4
122	Blue-winged Minla	0	0	0	0	0	0	0	0	0	1	0	0	1
123	Plain Flowerpecker	0	0	0	0	1	0	0	0	0	0	0	0	1
124	Chestnut-crowned Laughingthrush	0	0	0	0	1	0	0	0	0	0	0	0	1
125	Black-faced Warbler	0	0	0	0	1	0	0	0	0	0	0	0	1
126	Black-throated Sunbird	0	0	0	0	1	0	1	1	0	1	1	0	5
127	Black Francolin	0	0	0	0	0	1	0	1	1	1	1	0	5
128	Eurasian Crag Martin	0	0	0	0	0	1	1	0	0	0	0	0	2
129	White-capped Water-Redstart	0	0	0	0	0	1	0	1	1	0	0	0	3
130	Oriental Magpie-Robin	0	0	0	0	0	1	1	1	1	0	1	1	6
131	Black Kite	0	0	0	0	0	1	1	0	0	0	0	0	2
132	Black Bulbul	0	0	0	0	0	1	1	0	1	1	1	1	6
133	Scarlet Minivet	0	0	0	0	0	1	1	0	1	1	1	1	6
134	Black Drongo	0	0	0	0	0	1	0	1	1	0	1	1	5
135	Red-billed Blue Magpie	0	0	0	0	0	1	1	0	0	0	1	0	3
136	White-throated Fantail	0	0	0	0	0	1	0	0	0	0	1	0	2
137	Great Tit	0	0	0	0	0	1	0	1	1	1	1	1	6
138	Indian Cuckooshrike	0	0	0	0	0	1	0	0	0	1	1	1	4
139	Black Eagle	0	0	0	0	0	1	1	0	0	0	0	0	2
140	Grey Wagtail	0	0	0	0	0	1	0	1	1	0	0	1	4
141	Long-legged Buzzard	0	0	0	0	0	1	0	0	0	0	0	0	1
142	House Swift	0	0	0	0	0	1	0	0	0	0	0	1	2
143	Paddyfield Pipit	0	0	0	0	0	1	0	0	1	0	0	0	2
144	White-browed Shrike Babbler	0	0	0	0	0	1	0	0	0	0	0	0	1
145	White-rumped Munia	0	0	0	0	0	0	1	1	0	0	0	0	2
146	Red-headed Vulture	0	0	0	0	0	0	0	0	1	0	0	0	1
147	Crimson Sunbird	0	0	0	0	0	0	1	1	1	1	1	1	6

148	Slaty-backed Forktail	0	0	0	0	0	0	1	0	0	0	0	0	1
149	Common Myna	0	0	0	0	0	0	1	1	1	1	1	0	5
150	Blue Whistling Thrush	0	0	0	0	0	0	1	1	0	0	1	0	3
151	Common Tailorbird	0	0	0	0	0	0	1	1	1	1	1	1	6
152	Long-tailed Minivet	0	0	0	0	0	0	1	1	1	0	1	0	4
153	Barn Swallow	0	0	0	0	0	0	1	0	0	1	0	0	2
154	Kalij Pheasant	0	0	0	0	0	0	1	1	0	0	1	0	3
155	Bronzed Drongo	0	0	0	0	0	0	1	1	1	0	1	0	4
156	Dark-sided Flycatcher	0	0	0	0	0	0	1	1	0	0	0	0	2
157	White-browed Fantail	0	0	0	0	0	0	1	0	0	0	0	0	1
158	Orange-bellied Leafbird	0	0	0	0	0	0	1	0	0	0	1	0	2
159	White-crested Laughingthrush	0	0	0	0	0	0	1	1	1	0	1	0	4
160	Striated Bulbul	0	0	0	0	0	0	1	0	0	0	0	0	1
161	Lesser Racquet-tailed Drongo	0	0	0	0	0	0	1	1	0	0	0	1	3
162	Oriental White Eye	0	0	0	0	0	0	1	1	1	0	0	0	3
163	Lesser Yellownape	0	0	0	0	0	0	1	0	1	0	0	1	3
164	Spotted Dove	0	0	0	0	0	0	1	1	1	0	0	1	4
165	Black-chinned Babbler	0	0	0	0	0	0	1	0	0	0	1	0	2
166	Chestnut-headed Warbler	0	0	0	0	0	0	1	0	0	0	0	0	1
167	Ashy Drongo	0	0	0	0	0	0	1	0	1	1	1	0	4
168	Chestnut-bellied Rock-thrush	0	0	0	0	0	0	1	0	0	0	0	0	1
169	Blue-throated Barbet	0	0	0	0	0	0	1	0	1	1	1	0	4

170	Rusty-tailed Flycatcher	0	0	0	0	0	0	1	0	1	0	0	0	2
171	Jungle Owlet	0	0	0	0	0	0	1	1	1	0	1	0	4
172	Greater Flameback	0	0	0	0	0	0	1	0	0	0	0	1	2
173	Red-rumped Swallow	0	0	0	0	0	0	0	1	1	0	1	0	3
174	Asian House Martin	0	0	0	0	0	0	0	1	1	0	0	0	2
175	Grey-headed Woodpeaker	0	0	0	0	0	0	0	1	1	0	0	0	2
176	Common Pigeon	0	0	0	0	0	0	0	1	1	0	0	0	2
177	Rufous Treepie	0	0	0	0	0	0	0	1	1	1	0	1	4
178	Large Cuckooshrike	0	0	0	0	0	0	0	1	1	0	0	0	2
179	Hair-crested Drongo	0	0	0	0	0	0	0	1	0	0	1	1	3
180	Velvet-fronted Nuthatch	0	0	0	0	0	0	0	1	1	1	1	1	5
181	Yellow-footed Green Pigeon	0	0	0	0	0	0	0	1	1	0	0	0	2
182	Rufus-bellied Niltava	0	0	0	0	0	0	0	1	0	0	0	0	1
183	River Lapwing	0	0	0	0	0	0	0	1	1	0	0	1	3
184	Large Cormorent	0	0	0	0	0	0	0	1	0	0	0	0	1
185	Bar-winged Flycatcher Shrike	0	0	0	0	0	0	0	1	1	0	1	1	4
186	Fulvous-breasted Woodpecker	0	0	0	0	0	0	0	1	0	1	1	1	4
187	Blue Rockthrush	0	0	0	0	0	0	0	1	0	0	0	0	1
188	Black-throated Babbler	0	0	0	0	0	0	0	1	0	0	0	0	1
189	Greater Yellownape	0	0	0	0	0	0	0	1	0	0	1	1	3
190	Black-crested Bulbul	0	0	0	0	0	0	0	1	1	0	0	0	2

191	Oriental Scoop Owl	0	0	0	0	0	0	0	1	0	0	0	1	2
192	Whistler's Warbler	0	0	0	0	0	0	0	1	0	0	0	0	1
193	Little Cormorant	0	0	0	0	0	0	0	1	1	0	0	1	3
194	Copper Smith Barbet	0	0	0	0	0	0	0	1	0	0	0	0	1
195	Asian Plain Martin	0	0	0	0	0	0	0	1	1	0	0	0	2
196	Grey-bellied Tesia	0	0	0	0	0	0	0	1	0	0	0	0	1
197	Hume's Leaf-warbler	0	0	0	0	0	0	0	1	0	0	0	0	1
198	White-browed Wagtail	0	0	0	0	0	0	0	1	0	0	0	1	2
199	Black-backed Forktail	0	0	0	0	0	0	0	1	0	0	0	0	1
200	Tytler's Leaf-warbler	0	0	0	0	0	0	0	1	0	0	0	0	1
201	Grey-throated Babbler	0	0	0	0	0	0	0	1	0	0	1	0	2
202	Grey-breasted Prinia	0	0	0	0	0	0	0	1	1	1	0	0	3
203	Steppe Eagle	0	0	0	0	0	0	0	1	0	0	0	0	1
204	Grey Bushchat	0	0	0	0	0	0	0	1	1	0	1	0	3
205	Asian Brown Flycatcher	0	0	0	0	0	0	0	1	0	0	0	0	1
206	Black-hooded Oriole	0	0	0	0	0	0	0	0	1	0	0	1	2
207	Greater Coucal	0	0	0	0	0	0	0	0	1	1	0	1	3
208	Indian Pond Heron	0	0	0	0	0	0	0	0	1	0	0	1	2
209	Indian Roller	0	0	0	0	0	0	0	0	1	0	0	1	2
210	Blue-tailed Bee-eater	0	0	0	0	0	0	0	0	1	0	0	0	1
211	Long-billed Pipit	0	0	0	0	0	0	0	0	1	0	0	0	1
212	Goosander	0	0	0	0	0	0	0	0	1	0	0	1	2
213	Asian Woollyneck	0	0	0	0	0	0	0	0	1	0	0	1	2

214	Golden-throated Barbet	0	0	0	0	0	0	0	0	1	0	0	0	1
215	Green Bee-Eater	0	0	0	0	0	0	0	0	1	0	0	0	1
216	Green-billed Malkoha	0	0	0	0	0	0	0	0	1	0	1	1	3
217	Red Junglefowl	0	0	0	0	0	0	0	0	0	1	1	1	3
218	Jungle Babbler	0	0	0	0	0	0	0	0	1	0	0	1	2
219	Long-tailed Broadbill	0	0	0	0	0	0	0	0	1	0	1	0	2
220	White-throated Kingfisher	0	0	0	0	0	0	0	0	1	0	0	1	2
221	Rufous-gorgeted Flycatcher	0	0	0	0	0	0	0	0	1	0	0	0	1
222	Lineated Barbet	0	0	0	0	0	0	0	0	1	0	0	1	2
223	Greater Racquet-tailed Drongo	0	0	0	0	0	0	0	0	1	0	0	0	1
224	Large Woodshrike	0	0	0	0	0	0	0	0	1	0	0	0	1
225	Scaly-brested Munia	0	0	0	0	0	0	0	0	1	0	0	0	1
226	Small Minivet	0	0	0	0	0	0	0	0	1	0	0	1	2
227	Tickell's Leaf-warbler	0	0	0	0	0	0	0	0	1	0	0	0	1
228	Spotted Owlet	0	0	0	0	0	0	0	0	1	0	0	1	2
229	Little Egret	0	0	0	0	0	0	0	0	1	0	0	1	2
230	Asian-barred Owlet	0	0	0	0	0	0	0	0	1	0	0	1	2
231	Jungle Myna	0	0	0	0	0	0	0	0	0	0	0	1	1
232	Western Spotted Dove	0	0	0	0	0	0	0	0	0	1	1	0	2
233	Plum-headed Parakeet	0	0	0	0	0	0	0	0	0	1	0	1	2
234	White-bellied Drongo	0	0	0	0	0	0	0	0	0	1	0	1	2
235	Grey-capped Woodpecker	0	0	0	0	0	0	0	0	0	1	1	1	3

236	Scaly Thrush	0	0	0	0	0	0	0	0	0	1	1	1	3
237	Crested Serpent Eagle	0	0	0	0	0	0	0	0	0	1	1	1	3
238	Common Iora	0	0	0	0	0	0	0	0	0	1	0	1	2
239	Shikra	0	0	0	0	0	0	0	0	0	1	1	1	3
240	Sirkeer Malkoha	0	0	0	0	0	0	0	0	0	1	0	0	1
241	Rusty-Cheeked Scimitar Babbler	0	0	0	0	0	0	0	0	0	1	1	0	2
242	Puff-throated Babbler	0	0	0	0	0	0	0	0	0	1	1	1	3
243	Spiny Babbler	0	0	0	0	0	0	0	0	0	1	0	0	1
244	Chestnut-bellied Nuthatch	0	0	0	0	0	0	0	0	0	0	1	1	2
245	Grey-capped Emerald Dove	0	0	0	0	0	0	0	0	0	0	1	1	2
246	Orange-headed Thrush	0	0	0	0	0	0	0	0	0	0	1	0	1
247	Pied Thrush	0	0	0	0	0	0	0	0	0	0	1	0	1
248	Wedge-tailed Green-Pigeon	0	0	0	0	0	0	0	0	0	0	1	0	1
249	White-browed Scimitar Babbler	0	0	0	0	0	0	0	0	0	0	1	0	1
250	Nepal Fulvetta	0	0	0	0	0	0	0	0	0	0	1	0	1
251	Indian Peafowl	0	0	0	0	0	0	0	0	0	0	0	1	1
252	Red-wattled Lapwing	0	0	0	0	0	0	0	0	0	0	0	1	1
253	Common Woodshrike	0	0	0	0	0	0	0	0	0	0	0	1	1
254	Lesser Adjutant	0	0	0	0	0	0	0	0	0	0	0	1	1
255	Grey-headed Fish Eagle	0	0	0	0	0	0	0	0	0	0	0	1	1
256	Himalayan Flameback	0	0	0	0	0	0	0	0	0	0	0	1	1
257	Asian Openbill	0	0	0	0	0	0	0	0	0	0	0	1	1

258	Cotton Pygmy-goose	0	0	0	0	0	0	0	0	0	0	0	1	1
259	Great White Egret	0	0	0	0	0	0	0	0	0	0	0	1	1
260	Intermediate Egret	0	0	0	0	0	0	0	0	0	0	0	1	1
261	Common Greenshank	0	0	0	0	0	0	0	0	0	0	0	1	1
262	Oriental Darter	0	0	0	0	0	0	0	0	0	0	0	1	1
263	Black-crowned Night Heron	0	0	0	0	0	0	0	0	0	0	0	1	1
264	Common Kingfisher	0	0	0	0	0	0	0	0	0	0	0	1	1
265	Indian Pygmy Woodpecker	0	0	0	0	0	0	0	0	0	0	0	1	1
266	Great Hornbill	0	0	0	0	0	0	0	0	0	0	0	1	1
267	Pied Kingfisher	0	0	0	0	0	0	0	0	0	0	0	1	1
268	Green Sandpiper	0	0	0	0	0	0	0	0	0	0	0	1	1
269	Bar-headed Goose	0	0	0	0	0	0	0	0	0	0	0	1	1
270	Asian Green Bee-Eater	0	0	0	0	0	0	0	0	1	0	0	1	2
271	Red-Whiskered Bulbul	0	0	0	0	0	0	0	0	0	0	0	1	1
272	Alexandrine Parakeet	0	0	0	0	0	0	0	0	0	0	0	1	1
273	Pale Sand Martin	0	0	0	0	0	0	0	0	0	0	0	1	1
274	Chestnut-tailed Starling	0	0	0	0	0	0	0	0	0	0	0	1	1
275	Stork-billed Kingfisher	0	0	0	0	0	0	0	0	0	0	0	1	1
276	White-breasted Waterhen	0	0	0	0	0	0	0	0	0	0	0	1	1
277	Black-rumped Flameback	0	0	0	0	0	0	0	0	0	0	0	1	1
278	White-rumped Shama	0	0	0	0	0	0	0	0	0	0	0	1	1

279	Common Hill Myna	0	0	0	0	0	0	0	0	0	0	0	1	1
280	Orange-breasted Green Pigeon	0	0	0	0	0	0	0	0	0	0	0	1	1
281	Oriental Pied Hornbill	0	0	0	0	0	0	0	0	0	0	0	1	1
282	Changeable Hawk-Eagle	0	0	0	0	0	0	0	0	0	0	0	1	1
283	Blossom-headed Parakeet	0	0	0	0	0	0	0	0	0	0	0	1	1
284	Lesser Coucal	0	0	0	0	0	0	0	0	0	0	0	1	1

Annex 6. Bird Species occurred in each order and family

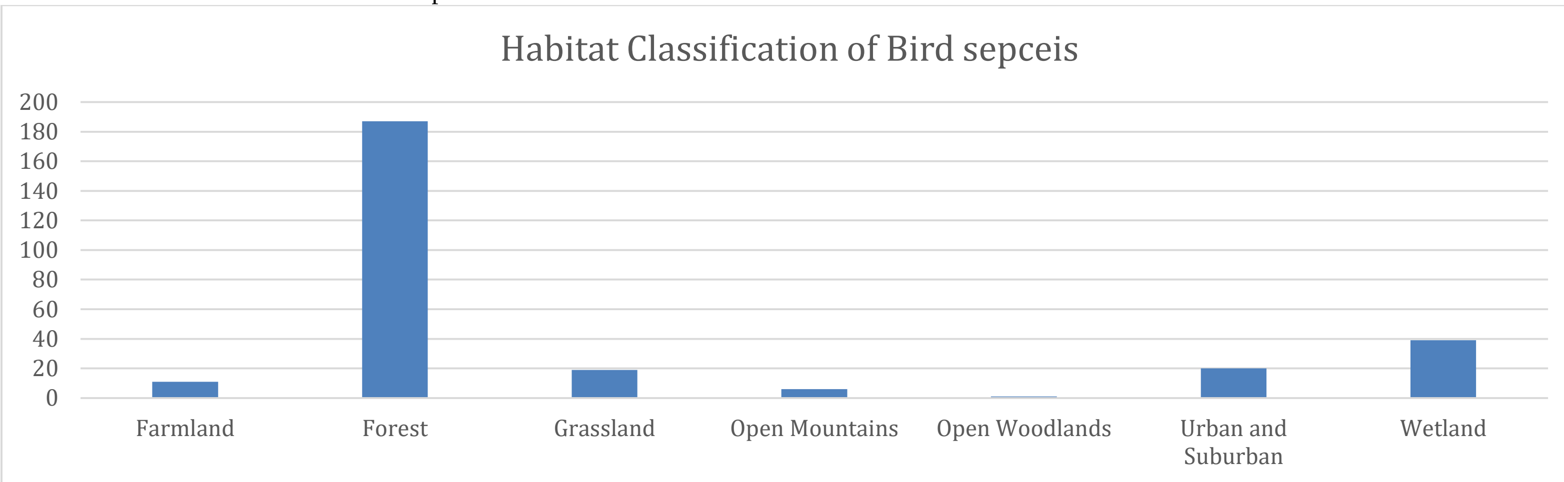
Order	Family	COUNT of Order
Accipitriformes	Accipitridae	15
Accipitriformes Total		15
Anseriformes	Anatidae	5
Anseriformes Total		5
Apodiformes	Anatidae	1
Apodiformes Total		1
Bucerotiformes	Bucerotidae	2
Bucerotiformes Total		2
Cariamiformes	Apodidae	1
	Falconidae	2
Cariamiformes Total		3
Charadiiformes	Charadriidae	1
Charadiiformes Total		1
Charadriiformes	Charadriidae	1
	Scolopacidae	2
Charadriiformes Total		3

Columbiformes	Columbidae	11
Columbiformes Total		11
Coraciiformes	Alcedinidae	4
	Coraciidae	1
	Meropidae	3
Coraciiformes Total		8
Cuculiformes	Cuculidae	4
Cuculiformes Total		4
Galliformes	Phasianidae	6
Galliformes Total		6
Gruiformes	Rallidae	2
Gruiformes Total		2
Otidiformes	Ciconiidae	3
	Threskiornithidae	1
Otidiformes Total		4
Passeriformes	Acrocephalidae	1
	Aegithalidae	1
	Aegithinidae	1
	Alaudidae	2
	Campephagidae	4
	Certhiidae	1
	Chloropseidae	1
	Cinclidae	2
	Cisticolidae	3
	Corvidae	11
	Dicaeidae	2
	Dicruridae	7
	Emberizidae	1

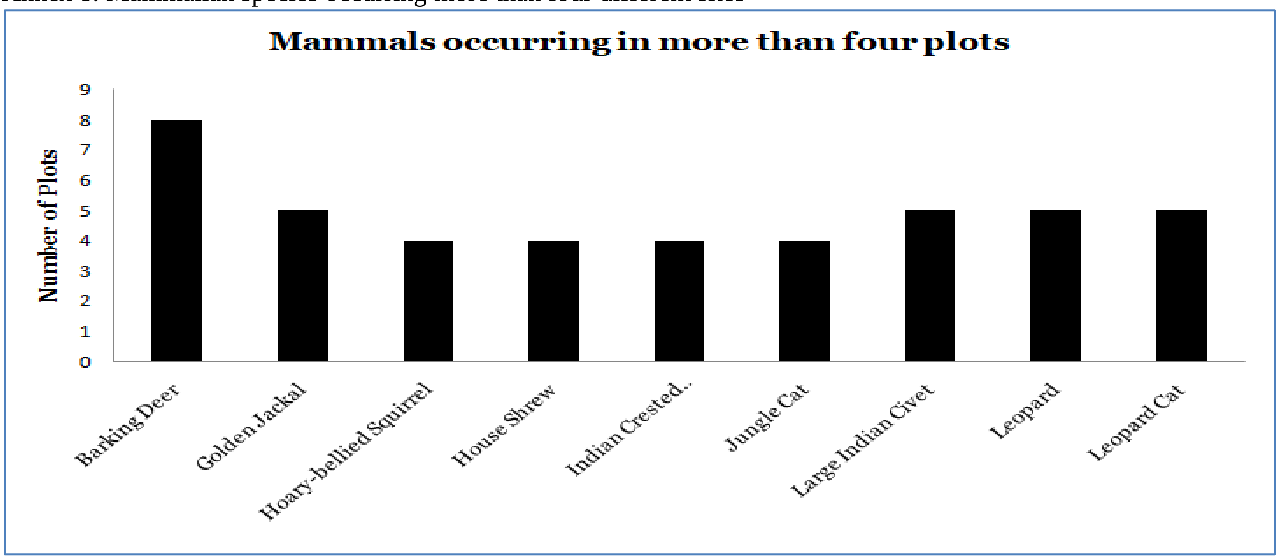
	Estrildidae	2
	Eurylaimidae	1
	Fringillidae	9
	Hirundinidae	7
	Laniidae	2
	Leiotrichidae	14
	Motacillidae	7
	Muscicapidae	25
	Nectariniidae	5
	Oriolidae	2
	Paridae	9
	Passeridae	2
	Pellorneidae	1
	Phylloscopidae	9
	Prunellidae	2
	Pycnonotidae	6
	Rhipiduridae	1
	Sittidae	4
	Stenostiridae	1
	Sturnidae	4
	Sylviidae	1
	Timaliidae	8
	Troglodytidae	1
	Turdidae	8
	Vangidae	2
	Vireonidae	3
	Zosteropidae	6
Passeriformes Total		179

Pelecaniformes	Ardeidae	5
	Phalacrocoracidae	1
Pelecaniformes Total		6
Piciformes	Megalaimidae	2
	Picidae	10
	Ramphastidae	3
Piciformes Total		15
Psittaciformes	Campephagidae	1
	Hirundinidae	1
	Psittacidae	4
	Psittaculidae	1
	Pycnonotidae	1
	Vangidae	1
Psittaciformes Total		9
Strigiformes	Strigidae	6
Strigiformes Total		6
Suliformes	Anhingidae	1
	Phalacrocoracidae	3
Suliformes Total		4
Grand Total		**284**

Annex 7. Habitat classification of Bird species



Annex 8. Mammalian species occurring more than four different sites



Annex 9. Number of Species occurred in each family in Butterflies species

Family	No. of Species
Hesperiidae	3
Lycaenidae	20
Nymphalidae	54
Papilionidae	3
Pieridae	18
Riodinidae	6
Unidentified	3
Total	107

Annex 10. Herpetofauna recorded in different plots:

S.N.	Common Name	Scientific Name	Order	family	IUCN	Site/code
1	Rock Agama	Laudakia tuberculata	Squamata	Agamidae	LC	Titi
2	Liebig's paa frog	Nanorana liebigii	Anura	Dicroglossidae	LC	Titi
					-	
1	Terai Criket Frog	Fejerverya terainsis	Anura	Dicroglossidae	LC	Bhadaure
2	Indian Skipper Frog	Euphlyctis cyanophlyctis	Anura	Dicroglossidae	LC	Bhadaure
1	Indian Skipper Frog	Euphlyctis cyanophlyctis	Anura	Dicroglossidae	LC	Harpankot
2	Asian Common Toad	Bufo melanostictus	Anura	Bufonidae	LC	Harpankot
3	Common Garden Lizard	Calotes versicolor	Squamata	Agamidae	Not Listed	Harpankot

1	Common Garden Lizard	Calotes versicolor	Squamata	Agamidae	Not Listed	Asardi
2	Bengal Monitor	Varanus bengalensis	Squamata	Varanidae	LC	Asardi
3	Indian Skipper Frog	Euphlyctis cyanophlyctis	Anura	Dicroglossidae	LC	Asardi
1	Indian Skipper Frog	Euphlyctis cyanophlyctis	Anura	Dicroglossidae	LC	Rampur
2	Fanged Frog	Limnonectes syhadrensis	Anura	Dicroglossidae	Not listed	Rampur
3	Asian Common Toad	Bufo melanostictus	Anura	Bufonidae	LC	Rampur
4	Amolops sp.	Amolops sp.	Anura	Ranidae		Rampur
1	Common Garden Lizard	Calotes versicolor	Squamata	Agamidae	Not Listed	Kabilas
1	Indian Rat Snake	Ptyas mucosa	Squamata	Colubridae	LC	Kaule
2	Common Garden Lizard	Calotes versicolor	Squamata	Agamidae	Not listed	Kaule
1	Gharial	Gavialis gangeticus	Crocodylia	Gavialidae	CR	Barandahar
2	Mugger Crocodile	Crocodylus palustris	Crocodylia	Crocodylidae	VU	Barandahar
3	Indian Softshell Turtle	Nilssonia gangetica	Testudines	Trionychidae	VU	Barandahar
4	Common Indian Skink	Eutropis carinata	Squamata	Scincidae		Barandabhar

Annex 12. Capacity Building Schedule

Session	Time	Time Frame	Content to be covered	Objectives	Methodology	Outcomes (things to be achieved by the end of this session)
1	11:00 AM	30 mins	**Orientation**	Participants' Introduction Explanation on objectives of the project and workshop	Presentation and Discussion	Registration and social interaction
2	11.30 -1:00	1.5 hr	**Overview on Climate Change**	Explain basic principles of Climate change, basic terms related to climate change	Presentation,	General awareness on cc,knowledge enhancement on situational comparison of cc impacts on biodiversity and local species
Lunch						
3	1:30 - 2:00	30 mins	**Demonstration on permanent plot**	Develop familiarity to permanent plot among participants	Practical hands-on demonstration	Participants will be familiar to the location and direction of permanent plots
4	2:00-3:30	1.5 hr	**Equipments (camera trap, mistnet, live traps, GPS), datasheet and field notes handling**	Equipments, datasheet and field note demonstration	Group work and group presentation	Participants will have basic knowledge on handling equipments, datasheets and field notes

Annex 13. Session plan

Orientation **Facilitator's Notes**	
[5 mins]	**Step 1: Welcome note** Provide a general welcome note to the participants for the session
[10 mins]	**Step 2: Introductions** Ask participants to introduce themselves. This might be done quickest by simply going around the tables and asking each participant to say their name and organization. A more interactive alternative is asking pairs of participants to talk to each other, find out why they are at this training and what they hope to get out of it.
[15 mins]	**Step 3: Introduction to the project** Introduce the learning objectives of the training module and the project
Overview on Climate Change **Facilitator's notes**	
Presentation [20 mins]	**Step 1: Basics of climate change** Through a presentation, summarize the basic science of climate change and global warming. Show video clips on global situations of climate change Use pictures and situational explanations on direct and indirect impacts of climate change on biodiversity and local species Use less text and more pictures and clips for the presentation
Q&A [10 mins]	**Step 2: Question and answer** Allow some time for questions and discussions
Discussion [30 mins]	**Step 3: Knowledge sharing** Involve participants to discuss the impacts of climate change they have experienced in their local environment. Make sure the participants are more involved than the facilitators
Exercise [30 mins]	**Step 4: Group work**

<table>
<tr><td></td><td>Form 3 groups of 5 members in each group. Provide each group with necessary stationaries required for the group work.
Ask each group to come up with one case scenario of climate change impact they have experienced in their community.
Inform the participants that the presentation will be done at the end of the workshop</td></tr>
<tr><td colspan="2" align="center">Demonstration on Permanent Plot
Facilitator's note</td></tr>
<tr><td>[15 mins]</td><td>Step 1: Demonstration
Topographic maps will be shown and demonstrated to the participants and explained by the facilitators</td></tr>
<tr><td>Exercise[15 mins]</td><td>Step 2: Mapping
Participants will be provided with A4 size papers and markers.
Individual participants will be asked to create a direction map from their house to the permanent plot area.
They will be jotting down landmarks, directions and others</td></tr>
<tr><td colspan="2" align="center">Equipment Handling and Management
Facilitator's note</td></tr>
<tr><td>Introduction [20 mins]</td><td>Step 1: Equipment, Datasheet and Fieldnotes Introduction
Facilitators will be demonstrating the equipment and their use to the participants.
Datasheet and fieldnotes will also be demonstrated to the participants to have them familiar with the documents.</td></tr>
<tr><td>Practical [30 mins]</td><td>Step 2: Self Exploration
Provide introduced equipment to the participants and let them explore camera traps, mist nets, live traps and GPS.
Facilitators should make sure they assist the participants</td></tr>
<tr><td>Presentation [30 mins]</td><td>Step 3: Group and individual presentation
First presentation will be by groups, demonstrating their case scenario.
Each group will get 5 minutes each.
Second presentation will be done individually. Each participant will present their maps, followed by a quick discussion.</td></tr>
</table>

[10 mins]	**Step 4: Closing Remarks** Give a closing remarks on the workshop

Annex 14. Local monitoring Protocol for indicator species

A. Snow Leopard (*Panthera uncia*)

Description: Has a luxuriant pale Smokey-grey coat with dark grey rosettes, black spots on limbs and face. Snow Leopards occur in cold, arid and semi-arid shrub land, alpine and subalpine areas, grasslands and open forests, favoring steep terrain characterized by cliffs, ridges, gullies and rocky outcrops at elevations of between 3,000 m and 5,500 m. A characteristic feature of snow leopard is extremely large size of their paw size than that of the other felids which have adapted to walk upon snow.
Key Identification Features:

- *Usually solitary, but cubs live with mother up to 1 year of age*
- *Average mass of the species is 35-45 Kgs*
- *Since it has unique plague they cannot be misidentified for other species.*

Threats:

- *Illegal hunting for body parts*
- *Habitat degradation and loss*
- *Decrease in Natural prey*

Monitoring Protocol:

Being a very shy and illusive species direct observation for the species is very hard. But opportunistic survey can be considered. When the organism is seen the data must be noted in the data sheet (Annex).Therefore, indirect sign survey for the species will be best for local people.

Sign Surveys:

It is impossible (at least impractical) to survey the whole habitat; Locals have knowledge about the tracks used by the species in its habitat. After the sites are known local people can select the trails for surveying the signs of the species in the trail. This method will provide the data about the presence absence and movement frequency of the species in the area. Furthermore, tracks can be marked by the biologists who are there to monitor the species and those trails and tracks are surveyed by the local people. At each site, information about the sign, date, elevation, habitat type, distance from human settlement are recorded in the data sheet provided (Annex). The types of the signs are listed below:

Figure 3: Scat of Snow Leopard

Scat:

Scat of adult snow leopard tends to uniform in diameter (i.e. an average of 1.8 cm) and comprises of slightly constricted cords or connected by blocky segments (up to 8-10 cm) with blunt ends (Fig 3). However, resemblance of some token scats with red fox scat may lead to false detection of the species.

Figure 1: Pugmark of Snow leopard

Pug-marks:

Imprint of the foot marks (Fig. 1) over suitable ground (Snow cover, muddy path). But there is always a chance that the pugmarks could be destroyed.

Scrape:

While marking their territory usually they scratch the ground with their hind limbs and urinate to leave their scent.

Figure 2: Snow leopard marking its Territory

Urine/Scent:

For marking snow leopards leave their scents in rock surfaces by urinating (Fig. 2). This can help to detect and identify the habitat of the species. Scent marking can be found in overhanging rocks.

Camera Trapping:
Upon the fixation of sites from the sign surveys, these areas are feasible for camera trapping. Camera traps are to be used in the tracks that are frequently used by the species. Snow leopard have different pattern of patches for each individuals which can help to identify. Camera trap can be placed at difference of 5 km between each camera trap.

For Habitat quality: Prey Abundance: Double observer method:
Population and behavior of prey influence the habitat quality of the predator species. In this method, two observers survey two different paths in the same study area scanning through the vantage points. In this period they note down the population of the prey species through scanning. Animals seen are noted individually for abundance estimation. The observer records group size, age group, sex ratio of the prey species. These data will help in understanding the quality of habitat for the species in the area.

Survey Period: January to Mid-March (Since this is the breeding season of the species the signs during this period are high in their areas).

B. Royal Bengal Tiger (*Panthera tigris*):
Description:
Royal Bengal Tigers live in humid evergreen forests, dry open jungle and grassy swamps of the Terai. The Terai grasslands, where a large percentage of tigers are distributed, are one of the most critically threatened tiger habitats in the world. They are very powerful animals can drag very large mammals (Gaur approx. 700 kg) by their necks. They have short thick neck, broad shoulders and massive forelimbs which are used for attacking and holding their prey. They have the tongue covered with hard papillae to scrape off the flesh of their prey from bones. In Nepal, Royal Bengal Tiger populations exist in fragmented locations in the Terai region and core sub populations are concentrated in the protected areas of Bardia National Park, Chitwan National Park, Parsa Wildlife Reserve and Shukla Phanta Wildlife Reserve and the districts of Banke, Bara, Bardia, Chitwan, Dang, Kailali, Kanchanpur, Makawanpur, Nawalparasi, Parsa and Rupandehi. Recently tiger have been reocred from dadeldhura district as well.
Key Identification Features:

- *Orange coat with black stripes*
- *The back of the ears are black with white spot*
- *Long banded tail*
- *White undersides.*

Threats:

- *Poaching and Illegal Trade*
- *Reduction in natural prey base*
- *Habitat fragmentation and modification*
- *Retaliation Killing due to conflict with humans*

Monitoring Protocol:

Being very illusive animal direct sightings of the animal are very rare. Though, opportunistic sightings could be better option for recording the presence and absence of the species. Other Sign surveys and Non-invasive sampling can be better option for local people to monitor the tiger

Sign Surveys:

Typically tiger move a great length 1-20km per day in search for their food and monitor their range. During this period the track is marked by their pugmarks and occasional scat deposit. Inside the park mostly tigers follow the fire lines in order to walk so signs like pugmarks and scats may be seen during the transect walk.

Pugmarks:

Figure 4: Pugmark of Tiger

A tiger's paw (Fig. 4) consists of a pad and four toes. A fifth toe commonly called the dew claw is placed high on the front limbs only. Dew claw is used for weaponry purpose but they do not land in the ground for making mark. Pugmarks of tigers can be searched in dusty or damp ground, forest paths and roads, animal trails, river and stream beds, near water holes, dry nala beds and In the vicinity of natural salt licks.

Scats and Scrapings:

Tiger monitor their area around same interval of time. They do marking of their territory with their urination and defecation (Fig.5). So these signs can help us to know the presence and absence of the species in the area.

Figure 5: Scraping and Marking of Tiger

Figure 6: Fresh Scat of Tiger

Information from local people:
Conflict with tiger is inevitable. Since they kill the domestic animals of local people, information from locals can help to know the presence absence of the data. But local can misidentify the species it can cause an issue.

Line transects:
Line transects can be created along the habitat and walked with noticing the abundance of prey species for tiger. This will help in evaluation the prey density for the species and quality of habitat for the species. Transects of 1-5 km may be created and walked.

Monitoring Time:
Regular monitoring of tiger signs (pugmark tracings) should be carried out at every guard post at weekly interval with monthly compilation of data. Sign surveys and individual tiger monitoring should become a regular task of every guard post. The monthly data should be mapped and maintained to analyze trends.

C. Himalayan Black Bear (*Ursus thibetanus*):
Description:
The Himalayan Black Bear occurs in dense, mixed broadleaf forests and steep forest hills, using rock caves and tree hollows as shelter. The Himalayan Black Bear occurs across the mid-hills and within all of the Himalayan Protected Areas (Kanchenjunga Conservation Area, Makalu-Barun, Sagarmatha, Langtang, Shivapuri Nagarjun, Shey-Phoksundo, Rara and Khaptad National Parks, and Annapurna and Manaslu Conservation Areas, and Dhorpatan Hunting Reserve) and from the districts of

Dhading, Surkhet, Dailekh, Dadeldhura, Doti, Bajura, Rukum and Myagdi. Although it is considered to occur mainly between elevations of 1,400 m to 4,000 m, it was recorded in Bardia National Park, Babai Valley in a 1999 camera trap.

Key identification Factors:

- *Large bear*
- *Short black fur, which is much shorter than that of the Sloth Bear, similar cream patch on chest*

Threats:

- *Poaching*
- *Habitat Loss*
- *Human-Bear conflict*
- *Natural system modifications*

Monitoring Protocol:

These animals are also very illusive and shy. They are dangerous as well so direct observation of the species is dangerous. For detection of the species indirect sign surveys can be done. Opportunistic sightings can be done if the species is observed at any time. These sign surveys can be conducted by establishing line transects along the habitat. Some of the sign surveys that can be followed are:

Hair Signs from bear rubs:

Bears generally rub their bodies around trees leaving their hairs. So these signs in transect can be noticed in order to understand the presence and absence of the species.

Diggings and claw marks around the trees:

Figure 7: Claw marking

Species dig grounds (Fig. 9) for roots and other eating things leaving markings of their claws (Fig.7). These species leave carvings in the trees as they climb which help us to know the presence of the species.

Figure 8: Bear biting

Figure 9: Bear Digging

Habitat:

Fruit trees, ant nests and termite nests can be counted along transects to obtain a measure of food abundance.

D. Asian Elephant (Elephas maximus)

Description:

Elephants are very important grazers and browsers, eating vast amounts of vegetation every day, spreading seeds around as they go. They also help shape the often-thick vegetation of the Asian landscape. Elephants will also dig for water when there isn't any surface water – opening water access for other creatures as well as themselves. This has made this species as an ideal species for monitoring the health of Terai Ecosystems. Asian Elephants are distributed across the Terai region of Nepal and estimated to be present within 22 districts of Nepal. They are present in Bardia National Park, Chitwan National Park, Koshi Tappu, Parsa and Shukla Phanta Wildlife Reserves. Movement of animals has been recorded between protected areas and adjacent forest patches within Nepal and parts of India with corridors connecting Shukla Phanta Wildlife Reserve to Bardia National Park and Dudhwa National Park and Katarniaghat Wildlife Sanctuary across the Indian border.

Key identification Factors:

- *Largest terrestrial mammal*
- *Grey wrinkled skin, long trunk and large ears*
- *Males have large tusks whilst females have small dental protuberances called tushes*

Threats:

- *Poaching for body Parts*
- *Habitat Loss*

- *Retaliatory killing due to conflict with Humans*

Monitoring Protocol:
For understanding the presence and absence of the species Line transect method can be used. In this method sign surveys like dung detection, footmarks near and around the water resources can be done. Opportunistic sightings can also be done to know the presence and absence of the data. Furthermore encounter rate of the species with local is high so information from the locals can also help in detection and movement of the species.

Dung Count:
Elephants dung can be identified easily (Fig. 10). Therefore dung count across transect can provide the status and movement of elephants around the study area. Indirect survey methods, such as dung count based methods, allow us to estimate animal abundance and density when the sign produced by the animals (dung piles in this case) are more easily detected than the animals themselves (e.g., because they live in concealing habitat types such as forests at low density or move away before they can be seen).

Figure 10: Elephant Dung

E. Greater One-horned Rhino (*Rhinoceros unicornis*):

Description:

The species inhabits the riverine grasslands of the Terai. It is found in the in alluvial plain habitats throughout their presence range. Adjacent swap forests are also used by the species. In Nepal, this species occurs in three locations: Bardia National Park, Chitwan National Park and Shukla Phanta National Park with occasional movement into Parsa Wildlife Reserve from adjoining areas of Chitwan.

Key identification Features:

- *Hairless slate grey skin which may be ashy when encrusted by mud or shiny black when washed by water*
- *Have a single dark horn on the nose*
- *Skin has large folds of skin across the body and tubercles resembling plates of armor*

Threats:

- *Illegal Hunting for body parts*
- *Habitat Degradation*
- *Flooding and Storms*

Monitoring Protocol:

Being a large bodied animal it can be detected in its habitat range. For the detection of the species some of the following locally adaptable methods can be done.

Transect walks:

Transects of 1-5 km may be created along the habitat and surveyed. Direct sightings of the species will provide presence and absence of the data. Rhinos normally graze actively in the morning hour so transect walk during this period will help to detect the species. During this period sex, size and shape of horn and ears can be noted. This will help in identification of the individuals.

Information from locals:

Mostly rhinos visit local people's field for grazing purposes. So this information from locals will help in detection of presence and absence of the species.

Sign Surveys:

Signs of dung (Fig. 12), footmarks (Figure 13) can be noted along transect to study presence and absence and rate of movement in the area. Mostly rhinos do latrines in a fixed place for some days continuously. So identification of these latrine sites can help in detection of the species.

Figure 12: Defecation site of One-horned Rhinoceros

Figure 13: Footmark of Rhino in swamp

F. Woolly Hare (Lepus oiostolus):

Description:

They are high altitude lagomorphs that are native to Tibetan plateau in Northern Nepal. They can be found in high altitude meadows, dry alpine steppes, grasslands, grassy marsh lands, shrubs, evergreen forests and sometimes in farmlands. They are important prey species for a number of medium to large bodied carnivores maintaining the healthy food chain of the ecosystem.

In Nepal, the species has been reported from Dolpa and Mustang districts, the Annapurna Conservation Area, Makalu Barun, Shey Phoksundo, and Sagarmatha National Parks and at elevations between 3,500 m and 5,500 m throughout the country.

Key Identification Factors:

- *comparatively larger than that of other lepriods species*
- *Plumb brown, thick curly fur, pale rump*
- *a tail that is brown above and of-white below*

Threats:

- *Human Killings for food*
- *Habitat Loss*

Monitoring Protocol:

These animals are found in high altitude meadows, they are encountered by locals. So interaction with the locals about the species will help in understanding the presence absence data of the species in the study area. Some of the methods that can be adapted by locals for monitoring are:

Line transects:

Transects in the highlands meadows can help in direct observation of the species in confirm the presence absence scenario of the species. Other signs surveys can also be done in those transects.

Pellet counting:

Identification of pellets of woolly hare will help in determining the density and habitat of the species. Pellet density counts are used for measuring the abundance and density of the species in the study area.

Live trapping:

Traps for the species can be provided to the locals. Live trapping are set in suitable sites and the individuals are captured for further monitoring the species.

Habitat quality:

Types of vegetations, weather and distance from the water resource can help in mapping the quality of habitat and changes occurring in the area.

G. Royle's Pika (*Ochotona roylei*):

They prefer rocky areas and nests in stone heaps. They occur in subtropical and tropical montane forests and talus. They inhabit the lower elevations than that of large eared pika.

This species has been reported from Langtang National Park, Rara National Park and Sagarmatha National Parks between elevations of 2,500 m and 5,000 m in Nepal.

Key identification Features:

- *fur is long, soft and fine and generally is of Rufus grey color*
- *Chestnut head, shoulders and upper back*
- *Red-purple throat and grey-white to dark grey underparts*

Threats:

- *Small stock lodging and livestock grazing*
- *Climate change (Ecosystem conversion)*

Monitoring Protocol:

Detection of the species is easy in its habitat, since they do not hide for long time in their burrows. They are seen frequently moving out of their hide.

Line Transects:

Line transects laid along the habitat will be useful for detection of the species. Normally when houses are near they can come into human contact as well, which will help in knowing the presence absence by direct observation of the species. They are usually active during dawn and dusk, so transect walk must focus this period for higher detection of the species.

Focal scan sampling:

Behaviors of Pika are noticed for fixed time from a fixed place. This will help us to understand the behavior of the species. Feeding behavior, hoarding behavior can be understood by applying this method.

Live Trapping:

Trapping can be done in order to know the more features about the species. Live traps can be laid as per the requirement but mortality must be less than 1 percent of the total capture.

Annex 15: Data sheet for sign survey

Observer:	Area:
GPS (Start):	GPS (End):
Time(Start and End):	Weather:
Total distance covered:	Date:

S.No.	Species	Sign Type	Elevation(m)	Latitude	Longitude	Aspect	Habitat Type	Distance from water resource	Type of disturbance

Annex 15: Data sheet for direct Observation

Observer:	Area:
GPS (Start):	GPS (End):
Time(Start and End):	Weather:
Total distance covered:	Date:

S.No.	Species	Number of individuals observed	Elevation(m)	Latitude	Longitude	Aspect	Habitat Type	Distance from water resource	Type of disturbance

Table 15: Data sheet for behavior study

Observer: Area:
GPS (Start): GPS (End):
Time(Start and End): Weather:
Total distance covered: Date:

Time	Individual	Type of behavior shown	Elevation(m)	Latitude	Longitude	Aspect	Habitat Type	Distance from water resource	Type of disturbance

(Types of behavior may be playing, fighting, making sound, running , feeding etc)

Photoplates:

Carnivore species in the camera trapping: Top row: (left to right): Tiger, Leopard, Jungle Cat, Leopard Cat, 2nd row: (left to right): Red Fox, Golden Jackal, Himalayan Black Bear, Yellow-throated marten, 3rd row (left to right): Crab-eating Mongoose, Masked Palm Civet, large Indian Civet and Small indian Civet

Other Camera trap species: Top row: (left to right): Terai Grey Langur, Rhesus Macaque, Assamese Macaque, Indian Hare, 2nd row: (left to right): Sambar, Greater One-horned Rhinoceros, Wild Boar, Asian Palm Civet, 3rd row (left to right): Spotted Deer, Barking Deer, Malayan Porcupine and Indian Crested Porcupine

Some of the glimpse of local monitoring mechanism and capacity development

Few fauna species recorded from the survey plot.

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